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IN THIS ISSUE

The Third Phase of Air Transport:

Jet Transport

VOLUME XI 3 MARCH 1956

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INTERAVIA

Review of World Aviation

Volume XI No. 3 March 1956

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Front cover :

More than 1,200 Boeing B-47 Stratojet six-jet bombers have already been built—a firm foundation for development and operation of transcontinental commercial jets. Picture shows a B-47 in a short take-off with the aid of RATO rockets.

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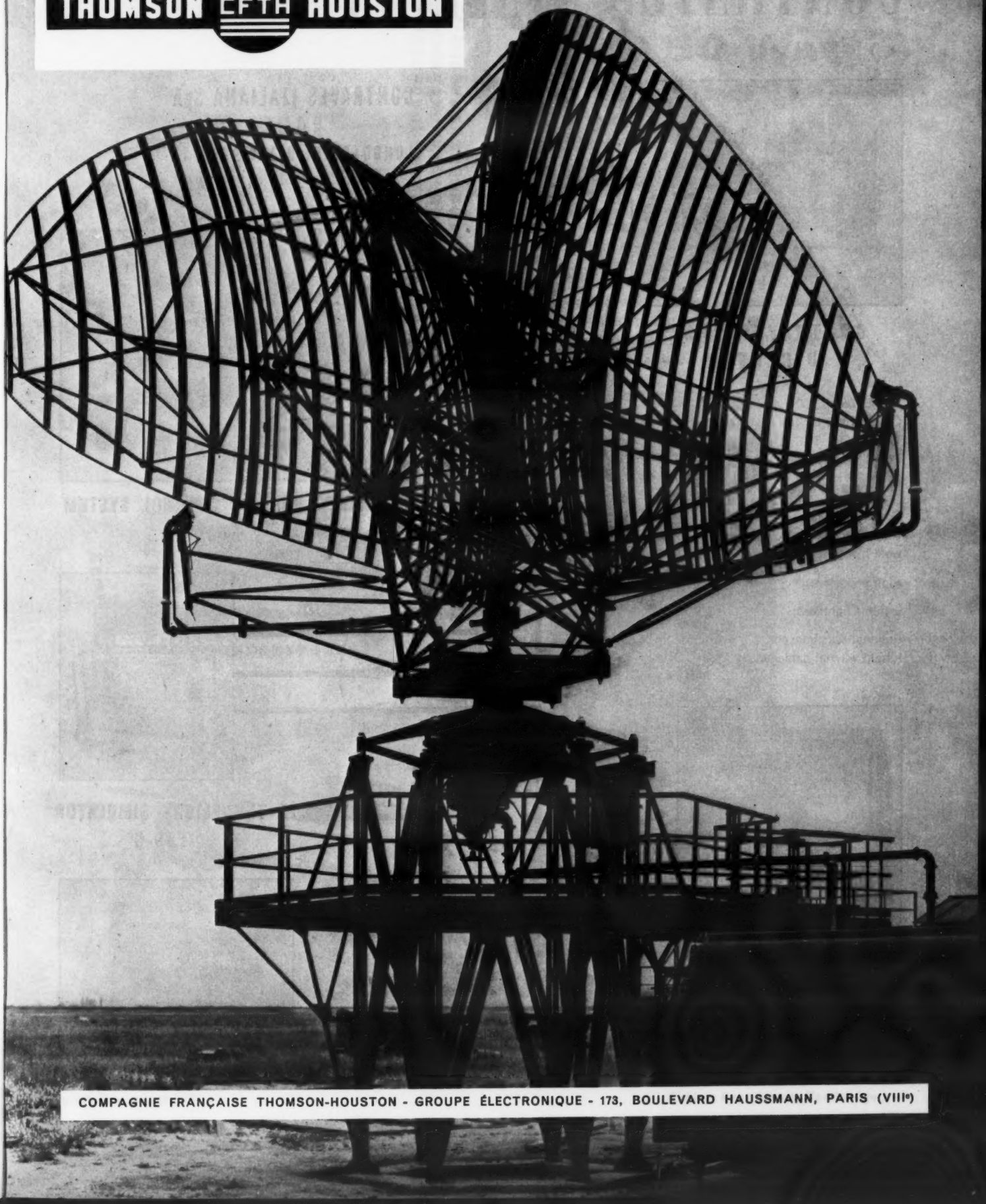

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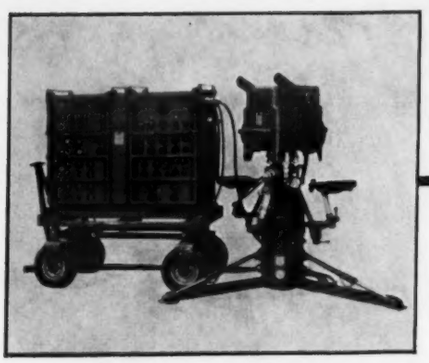

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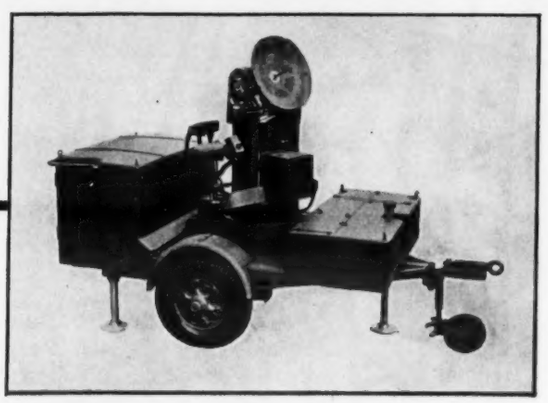

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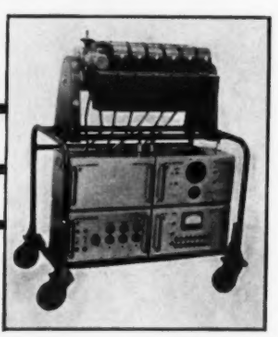

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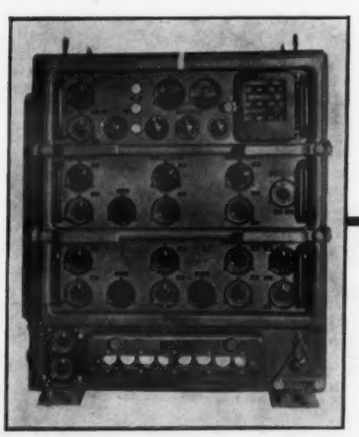

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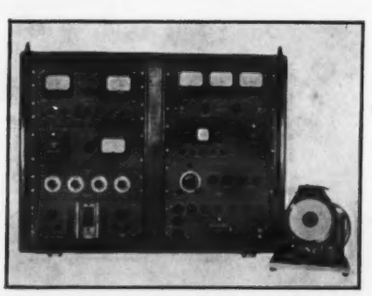

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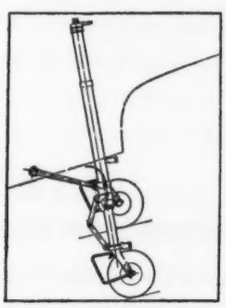
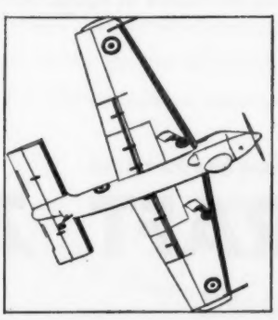
Because of its low landing speed, the Seamew can alight in an extremely small area. Tyre sizes can be easily changed to suit terrain.



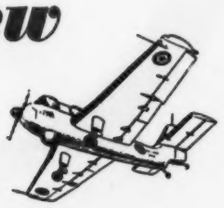
The two position tail wheel gives the advantages of a tricycle undercarriage layout for landing, while retaining the desirable features of the normal undercarriage for take-off.

Seamew—a tough, economical, all-weather submarine hunter. From an emergency coastal airstrip the Seamew can be airborne in a short distance to operate a wide-ranging patrol. It can conduct a maritime search with up-to-date radar equipment and use a variety of weapons to effect a kill. However rough-and-ready the airstrip, it can land back safely — with its low stalling and landing speeds and fixed, rugged, shock-absorbing undercarriage.



Generous flap surfaces contribute to the very low stalling and landing speeds. The Seamew is easy to fly and exceptionally manœuvrable.

The *Short* answer is the *Seamew*



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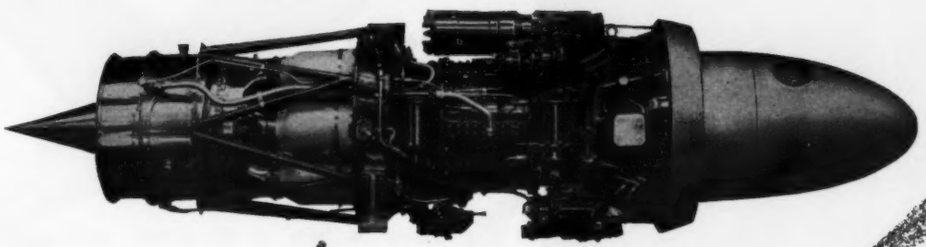

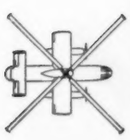

ELAND A Convair 340 aircraft converted to Eland engines will be on demonstration flights in Europe and the U.S. during this year. Another aircraft powered by *Elands* is the Elizabethan, converted for freighter evaluation. Napier *Elands*, fitted with auxiliary compressors for the tip-powered rotor system, will be mounted in Fairey's new large transport helicopter, the Rotodyne.

ORYX Two Napier *Oryx* engines are being mounted in the new Percival P74. Napier worked with Hunting Percival in the development of the *Oryx* which is a 750-825 gas h.p. turbo-gas-generator. This new Napier power unit eliminates all mechanical transmission.

GAZELLE The *Gazelle* is another Napier engine which is going places. Two *Gazelles* are mounted vertically in the new Bristol twin rotor helicopter, whilst other designs to be powered by this engine are well advanced. The engines are directly connected to the rotor heads, providing mechanical transmission in its simplest form.

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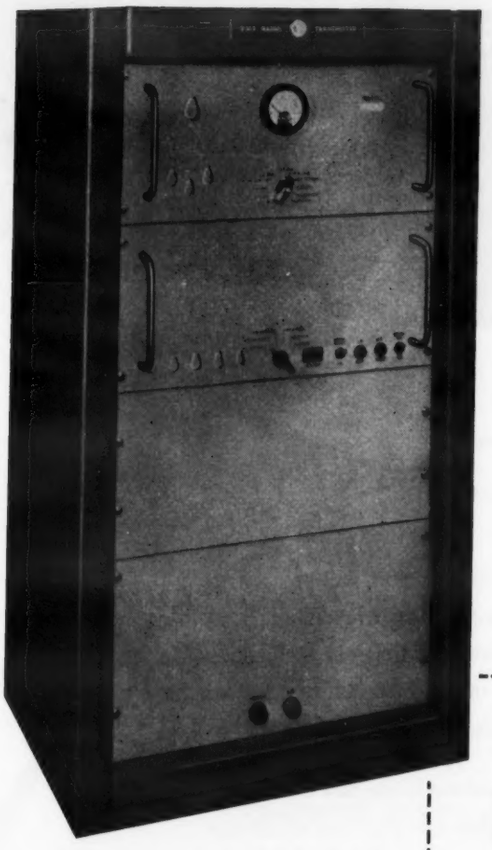

Shown above is the type AD 801 transmitter. It is compact and sturdy and, when fitted with shock absorbers, suitable for mounting in a vehicle. On the right is the type AD 818 receiver designed for aerodrome use in association with the AD 801 transmitter.

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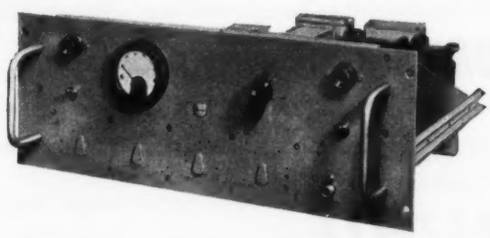

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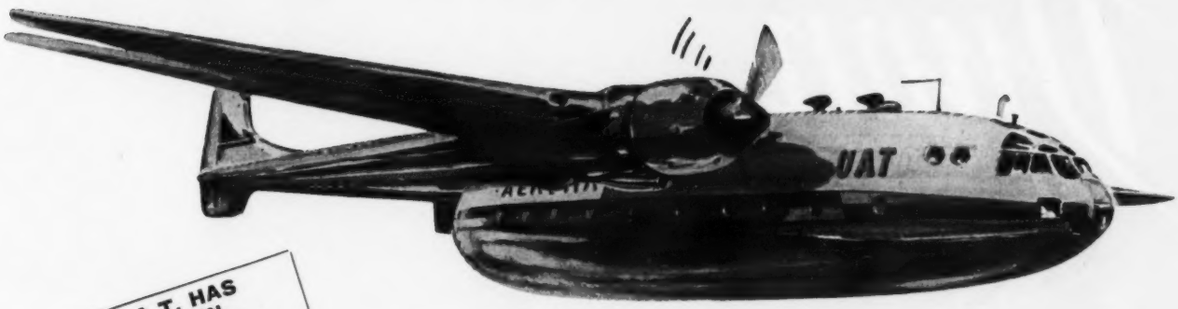

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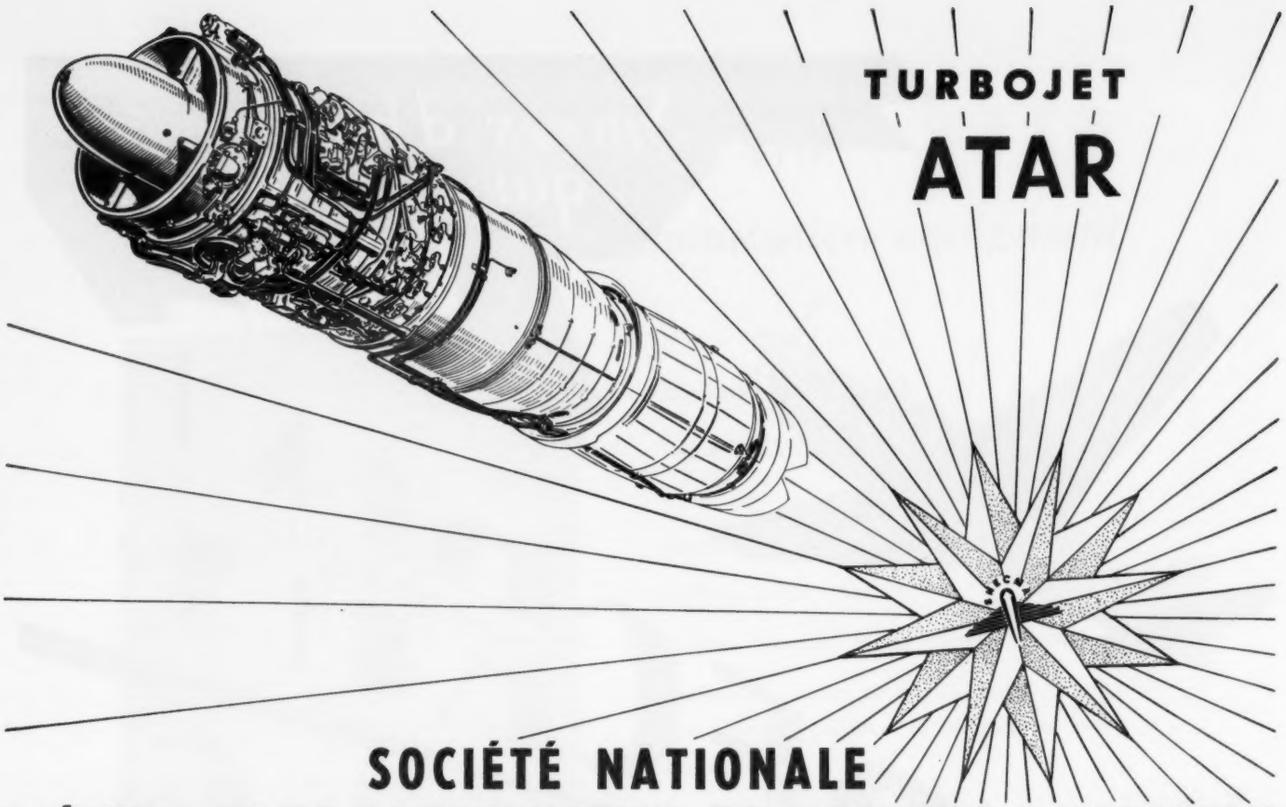

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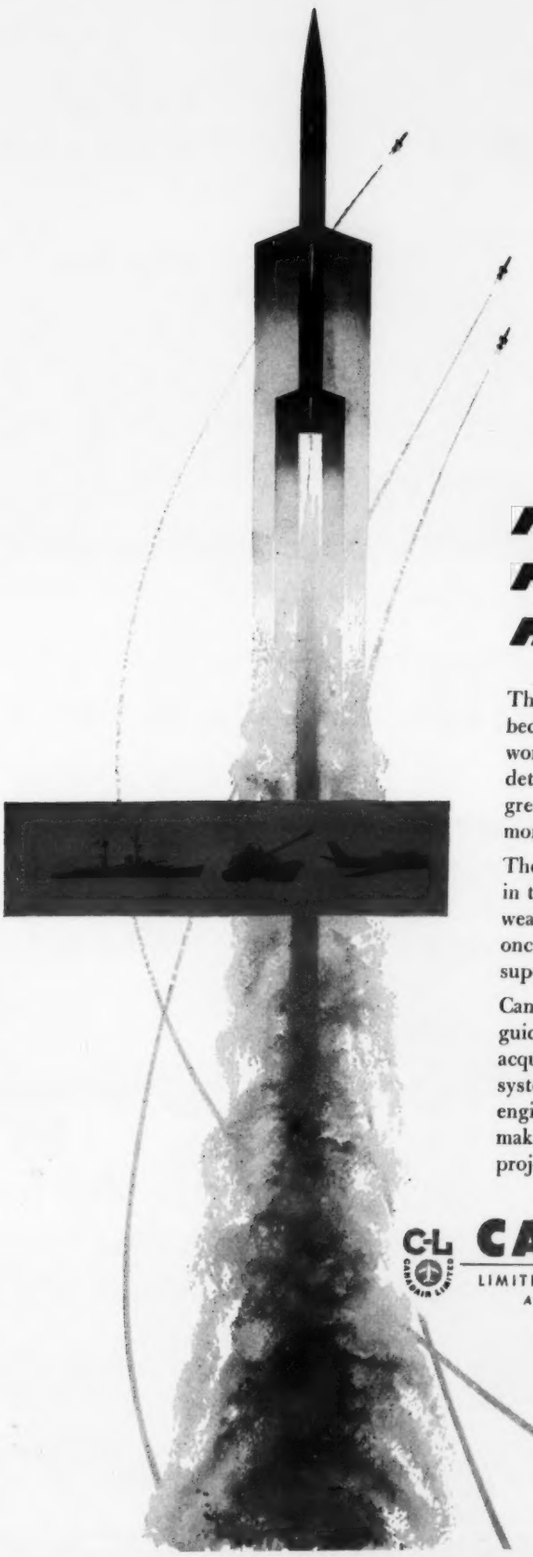

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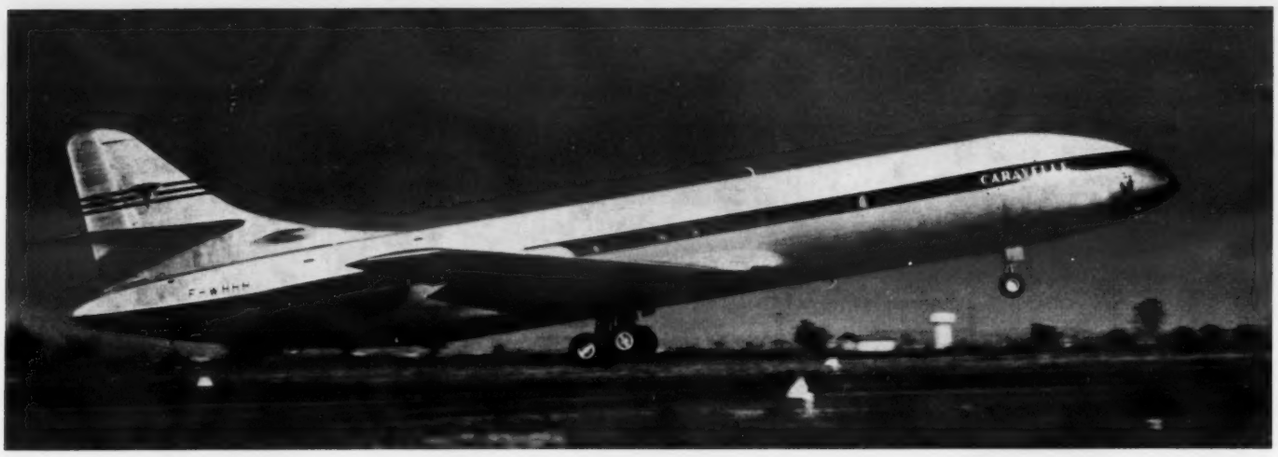

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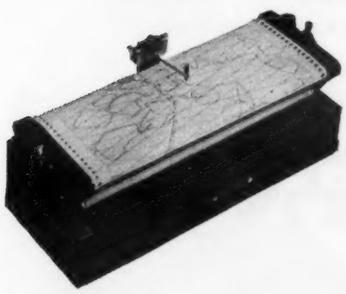
SAFE LANDING AFTER 3 ENGINES FAIL

Statement by CAPTAIN E. WATTS, BEA, *on his emergency landing in Cazaux airfield, Bordeaux, on 2nd January, 1956.*

During my incident on the 2nd January I was fortunate enough to have a Decca Navigator on my machine. I say fortunate for although I had a very competent crew the additional advantage of having a visual check on my position was invaluable. When the trouble developed I set course for Bordeaux purely on Decca, later checking by beacons and bearings. We were flying over eight-eights cloud during most of the descent and at one stage I was told I had actually crossed the coast, I glanced at Decca which gave me a position some 35 k/m from the coast, I decided to believe this and continued to hold as much height as was possible. Some seconds later we broke cloud over the sea thus proving Decca to be right. I was very happy indeed to have had the additional crew member along with me, namely Decca.



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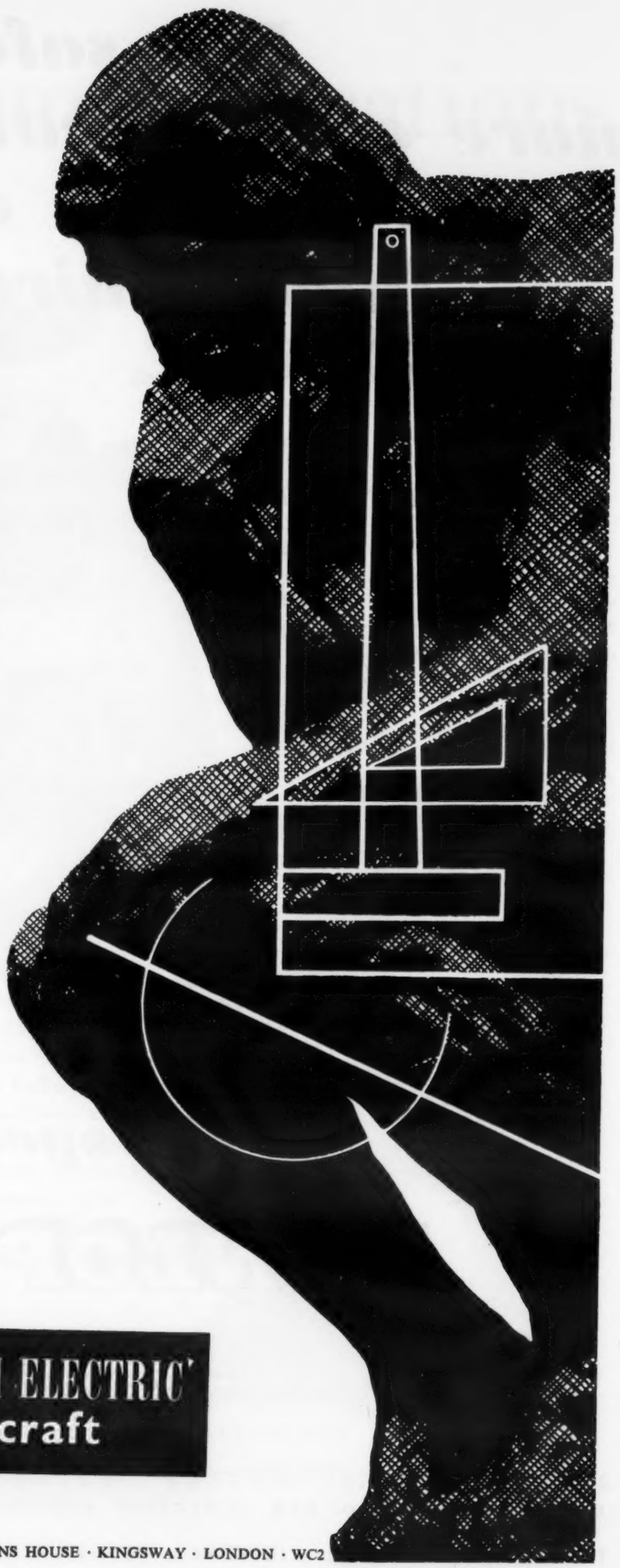

Design starts from an attitude of mind

THE REAL STARTING POINT of aircraft design at ENGLISH ELECTRIC is not a piece of drawing paper but an attitude of mind.

There was a time when admirable aeroplanes were designed by drawing (and re-drawing) until their nicely flowing curves were good to look at. This simple philosophy lasted surprisingly long, but it had unhappy side-effects. It inspired some unthinking people to believe that the intuition of an artist was a satisfactory substitute for the enquiring mind of the scientist. What worked—generally, but not always—in the low-subsonic piston age doesn't work today. Today there is *no* substitute for knowledge. Today the tools of the design team are the same as the tools of the scientist—analogue computors, supersonic wind-tunnels, electronic laboratory gear, harmonic analysers, cathode ray oscilloscopes and the kitchen stove and refrigerator (in larger and more highly-developed forms). But even then what finally matters is the team's attitude of mind towards its tools.

Our attitude at ENGLISH ELECTRIC is one of open-minded enquiry into what is a dauntingly big and complex problem. There are no tools we will not use—even if we have to invent them first—to find out all we have to find out ; and there is no substitute for finding out. Before ever a new aeroplane flies, it must have been 'flown' on the ground until nothing that is knowable without test flying is left unknown.

This is a long and costly business—but today it is less long and far less costly than relying on a hunch and a hope.

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INTERAVIA

Deadline Notes

No. 3, 1956

AN AIR TRANSPORT AGREEMENT has been signed between Egypt and Poland, authorizing the Polish airline LOT to operate a thrice-weekly service between Warsaw and Cairo.

THE PROPOSED 10% INCREASE IN FIRST-CLASS FARES over the Pacific and Atlantic has been "temporarily" agreed to by the U.S. Civil Aeronautics Board. Approval has been granted for the period April 1st to September 30th, 1956.

CAMBODIA has become the 67th member state of the International Civil Aviation Organization.

THE PRE-WAR DOUGLAS DC-3 is still the aircraft used in largest numbers by United States domestic airlines: 299 out of the total of 1,398 aircraft operating domestic services.

ALL JET AIRCRAFT will take off and land "almost vertically" in about thirty years, forecasts General Milton W. Arnold, Vice-President of the Air Transport Association of America.

THE U.S. CIVIL AERONAUTICS ADMINISTRATION has set aside $38,932,000 for the expansion of airports up to June 30th, 1956. The programme covers 319 airports, including New York International Airport.

LIQUIDATION OF ALA LITTORIA: The Italian Government has asked Parliament for a further 125,000,000 lire for the liquidation of Ala Littoria. Before World War II the airline operated a route network of 46,207 km with 133 aircraft. During the war it sustained losses amounting to 6,600,000 lire (1944 value).

THE AMERICAN AIRCRAFT INDUSTRY delivered a total of 4,753 civil aircraft in 1955, to a value of $271,010,-000, compared with 3,389 aircraft valued at $295,738,000 in 1954. Backlog of orders for civil aircraft at the end of 1955 was 752, an increase of 20% over the number at the end of 1954.

BOEING AIRPLANE CO. AND DOUGLAS AIRCRAFT CO. are running neck and neck in the race for jet transport orders. After T.W.A.'s contract for 30 Boeing 707s and Delta Airlines Inc.'s order for six Douglas DC-8s, totals now stand at 103 jetliners for Boeing and 104 for Douglas.

THE GLENN L. MARTIN CO. has received authorization from the U.S. Government to build a large guided missiles centre at Denver, Col. The cost of the complete installation is not yet known, but an initial expenditure of $10,000,000 is scheduled. Martin, which is already involved in the earth satellite programme, is also expected to participate in the development of the airframe for an intercontinental missile.

BOEING AIRPLANE CO. plans to expand its Renton plant, south of Seattle, by building a new facility chiefly for the assembly of body sections for the 707 jet transport. Cost, $8,500,000.

ROLLS-ROYCE LTD. is building a nuclear engineering laboratory in Derby. The company has been working on the application of nuclear energy to aircraft propulsion and related fields for the past 18 months and is applying its experience to the development of light-weight reactors.

DECCA RECORD CO. has decided to raise its share capital by £1,000,000 to £3,058,427 by the issue of 5,000,-000 shares at 4 shillings par.

ENGLISH ELECTRIC CO. announces a net profit of £2,858,632 for 1955, compared with £2,104,219 for the 1954 business year. Total dividend for the year 12 1/2 percent. Share capital was raised during the year from £10,-416,291 to £15,221,721. - Gross sales £6,570,601 (£5,371,281); depreciation £1,894,656 (£1,557,676); taxation £3,471,954 (£3,041,462); reserves £242,014 (£225,600).

THE DORNIER WORKS, Friedrichshafen, have received from the West German Defence Ministry an order for 428 Dornier Do 27 four-seat communications and training aircraft. The West German aircraft industry expects to receive further orders to a total value of DM 120,000,000 (production of foreign types under licence, maintenance and repairs).

A MEDICO-PHYSIOLOGICAL SECTION has been set up at the Brétigny Flight Test Centre, France. Equipment: a Latécoère centrifuge for 40 g accelerations, two low-pressure chambers and improved installations for simulating atmospheric conditions at high altitudes.

* From INTERAVIA's world-wide news service, including INTERAVIA AIR LETTER, the daily international aviation news digest. — No part may be reproduced without written permission.

NORTHROP SM-62 SNARK: First pictures of this guided missile have been released for publication by the U.S. Air Force. The Snark carries an atomic warhead. Range: 5,000 miles.

THE FIRST RB-66 RECONNAISSANCE VERSION of the twin-jet Douglas B-66 bomber has gone into service with the U.S. Air Force. This puts an end to persistent rumours that the RB-66 could not be made operational because of technical difficulties. According to the makers, the RB-66 operates at speeds of 600 to 700 m.p.h. at altitudes in excess of 50,000 ft.

A FAIRCHILD C-123 twin-engined transport wing has been allotted to the United States Air Force in Europe. The aircraft can carry up to 60 fully-equipped troops.

A NEW RECORD for the London-Cairo route has been set up by an English Electric Canberra. Flying time: 3 hours 59 mins. 9 secs. The previous record of 5 hours 7 mins. was held by a de Havilland Comet 1.

AIR BASES IN ITALY: Naples-Capodichino air base is to be evacuated by the Italian Air Force and converted into a purely civil airport. Units of the 4th Air Force Brigade stationed there will be transferred to Pratica di Mare, southwest of Rome. New military airfields are to be constructed at several localities on the Adriatic coast, including Rimini and Cervia.

THE DOUGLAS PLANT AT LONG BEACH AIRPORT, California, is to be the site of the final assembly of the DC-8 jet airliner. The Long Beach municipality has approved a $5,500,000 bond issue for the expansion of the airport which had been set as a condition by the company.

EGYPT'S AIRLINE MISRAIR is to open a thrice weekly Cairo-Rome service on March 19th, with extension to London in May. At the same time services will start on the following routes: Cairo-Khartoum-Jedda-Asmara; Cairo-Beirut and Cairo-Benghazi-Tripoli-Tunis. The company will use its three Viscounts and seven Vikings on these routes (a fourth Viscount is due to be delivered before the end of the year); several Fairchild UC-45s will be converted into freight transports. - Misrair has a capital of 1,500,000 Egyptian pounds which is to be raised to 2,000,000 in 1957 and 3,000,000 in 1958.

BRITISH AVIATION EXPORTS totalled £7,117,924 in January 1956, some £2,714,986 more than in the same month last year. This is the highest monthly total ever recorded by the industry.

*

WORKSHOP BRIEFS . . .

Flight testing of the first Vickers Viscount 700D (for Capital Airlines) has begun. The first 700D for Central African Airways should also have been completed by the time these lines appear. - Three standard versions of the 700D series have so far been developed: Viscount 700D (for non-American companies), Viscount 770D (for North American companies) and Viscount 771 (for North American companies, with luxury cabin equipment). * The sales price of a North American F-100 Super Sabre jet fighter is approximately $640,000. * The Airborne Computers Laboratories of International Business Machine Corp., New York, have developed a new electronic navigation and bomb sight equipment particularly suitable for use in supersonic bombers (B-52). It makes bomb-dropping over the target entirely automatic. * The U.S. Air Force has provided a Boeing B-47 jet bomber for the testing of Canada's Avro PS-13 turbojet (more than 19,000 lbs. thrust). The bomber is being converted into a flying test bed by Canadair Ltd. The PS-13 is destined to power the Avro CF-105 delta-wing supersonic fighter. * Britain's Fairey Aviation Co. is producing an air-to-air guided missile known as Fireflash under Ministry of Supply contract for the R.A.F. The Fireflash has a powder-propellant rocket motor and is built for speeds of Mach 1 plus. * A Dassault Super Mystère has reached Mach 1.35 in a glide. * Thrust of the Rolls-Royce Conway by-pass engine is officially given as 13,000 lbs.; length 128.8 ins., diameter 41.5 ins.; annular combustion chamber. * Ten Fokker S.14 Machtrainer jet trainers have so far been taken over by the Royal Netherlands Air Force. Altogether the R.N.A.F. has ordered twenty of these aircraft. * An additional order for Lockheed WV-2 (Super Constellation) early warning radar aircraft, to a total value of $60,000,000, will keep this type in production until the end of 1957. The WV-2 is powered by 3,250 h.p. Wright compound engines and is manned by a crew of 31. * Chance Vought is working on the development of a U.S. Air Force version of its F8U-1 Crusader Navy fighter. * Several U.S. aircraft manufacturers have received development contracts from the U.S. Army for a STOL aircraft (Short Take-Off and Landing). * The first Bréguet 1050 anti-submarine aircraft will be ready for flight by the end of the summer. A pre-production batch is being built. * The second Fairey Delta 2 prototype flew for the first time on February 15th, when it exceeded Mach 1 in level flight.

* * *

The Third Phase of Air Transport

A surprise that wasn't

It has been hanging on the wall in *Interavia's* reception room for more than two years . . . At Christmas 1953 Douglas Aircraft had presented its business friends throughout the world with a hand-painted hanging plate. Times have changed. It is not Limoges, Meissen, Delft, Derby or Copenhagen porcelain but native Californian pottery. The four aircraft depicted on it included a four-jet commercial transport. Those who had eyes to see, saw and understood. For the benefit of readers, the plate is reproduced here. That was in 1953. An artist's forecast has meanwhile been turned into tangible orders.

In July 1954 another American four-jet transport, known as the Boeing 707, flew for the first time on the U.S. West Coast. As tests proceeded satisfactorily the U.S. Air Force began to show interest, placed a sizeable order for the tanker-transport version of this aircraft and forebade its supply to commercial operators.

On June 14th, 1955, Douglas got busy and announced with the necessary fanfare that the firm had decided to offer to airlines the jet aircraft pictured on the 1953 hanging plate, with delivery from 1958 onwards.

Not to be outdone, Boeing announced two days later, on June 16th, to an astonished public—including Douglas—that the then Air Force Secretary, Harold E. Talbott, had reversed his earlier decision, the Boeing 707 was no longer an Air Force monopoly, and civil versions would also be built. First deliveries 1958, first operations 1959.

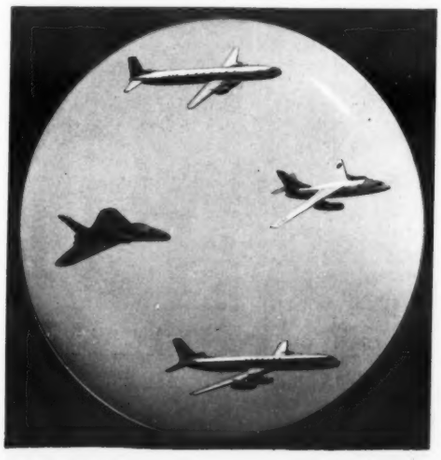
In dimensions and performance the two rivals are externally almost as like as two peas. Airlines could therefore order, let us say, which ever pleased them better. Douglas could claim that it had the greatest experience as supplier of commercial transport aircraft, from the DC-2 to the DC-7. Boeing in turn could maintain that it was the expert in heavy multi-jet aircraft, and its prototype had already flown several hundred hours over a period of eighteen months.

Both manufacturers, however, had proceeded with inexorable logic in one point: they had postponed their decision to build jet transports until sufficiently powerful, proven jet engines were really available.

Several months passed. Then, on October 13th, 1955, Pan American World Airways issued a statement: the jet transport age had begun, P.A.A. had drawn its practical conclusions and ordered twenty Boeing 707s and twenty-five Douglas DC-8s to a total value of $269,000,000, with delivery dates between December 1958 and December 1959.

Three days later the representatives of some 70 leading world airlines sat, pleasantly smiling, but with signs of a certain nervousness, round the table in New York's Waldorf-Astoria Hotel at I.A.T.A.'s Annual General Meeting. Some of them seemed to be in a hurry to get to warmer climes, to the West Coast, to see what was going on at Boeing in Seattle and Douglas in Santa Monica. They wanted to know all about these jet aircraft and they wanted to prevent their colleague Juan Terry Trippe of P.A.A. from getting ahead of them in the air transport race set to begin somewhere about 1960. The visitors found their trip to the West Coast somewhat costly—as the list below illustrates. For the hosts in Santa Monica and Seattle the invitation to the airline bosses proved rewarding. By February 15th, 1956—that is, within four months—Douglas and Boeing had booked orders for 221 four-jet commercial transports officially valued at a minimum of $1,300,000,000. Never had there been such a boom.

The painted plate . . . The Douglas DC-8 jet transport figured amongst other recent Douglas odels on the hand-made hanging plate which Douglas Aircraft Co. sent as a Christmas greeting to its friends in 1953. Its artistic prophesy differed little from the imminent reality.



Yet all this is not really surprising. What is more, it is not the first time that something similar has happened.

When in 1935 the relatively small firm of Douglas Aircraft brought out the DC-3, the first more or less economic and reliable commercial aircraft—after the three-engined Junkers Ju 52—and actually found customers for it, many warning voices were raised. It was calculated that the world market could absorb at best fifty DC-3s, that it would not be possible to fill these aircraft or to find a thousand passengers day after day for the world's air services. That was twenty years ago, and the DC-3 has already gone down in history. Roughly 11,000 of these aircraft were built, of which some 3,000 were bought by the airlines; the rest were absorbed by the military services during the war and many are still flying.

After the war, when Lockheed offered for sale its four-engined *Constellation,* Douglas its DC-6 and Boeing its *Stratocruiser*—all of them long-range aircraft with pressure cabins—the market did seem to be saturated. In the spring of 1947, for example, there were sixteen *Constellations* standing on the apron at Lockheed's Burbank Air Terminal waiting for purchasers. The reasons for the subsequent change in the situation need not be repeated here, but the fact remains that between 1949 and 1955 commercial aircraft, particularly for long ranges, came to be in short supply.

To sum up, the advent of the twin-engined Douglas in 1935 introduced the first phase of true scheduled air transport. The second phase began in 1946 with the American four-engined machines for transcontinental and overseas operations. And a third phase has just been heralded for about 1960. The age of jet transport has begun.

Money is no object . . . we have to borrow anyway

Our friends of *Aviation Week* were the first to quote an anonymous American airline president whose statement—which meanwhile has become slightly hackneyed—deserves repetition: ". . . We are buying airplanes that haven't yet been fully designed with millions of dollars we don't have and we're going to operate them off airports that are too small in an air traffic control system that is too slow, and we must

Jets or nothing . . . Signing jet orders worth $100,000,000 for ten Boeing 707 four-jet transports and twelve SE *Caravelle* twin-jet airliners, plus options.
Seated, left to right: Wellwood E. Beall, Senior Vice-President, Boeing Airplane Co. (not to be mistaken for Ralph L. Bell, Director of Commercial Sales); Louis Lesieux, Director-General of Air France; Max Hymans, Chairman of Air France; Georges Héreil, Managing Director of S.N.C.A.S.E. ("Caravelle"). – *Standing, third from left to right:* Raymond Dupré, Deputy Director-General of Air France (author of an article in this issue); Maurice Lemoine, Secretary-General of Air France; M. Montarnal, Director of Finance, Air France; M. Giusta; *at left,* two Boeing representatives.

fill them with more passengers than we've ever carried before!" If this statement was ever really made, and its author nevertheless ordered four-jet transports, he should either resign immediately or be removed by his directors for reckless conduct of his business. It must, however, be conceded that a great many improvements must be made on the ground before these aircraft come into service. It is also true that new passenger resources will have to be tapped for them. On the other hand, as the articles on the following pages show, if these aircraft are properly operated they can make air transport a truly economic proposition for the first time. But they also insist that many reforms must be made in preparation for the new phase. This is one of the reasons why *Interavia's* Editors decided to devote the March and April issues to this revolutionary problem.

An entirely new tune will have to be played in air transport. The day of eternal lamentation is past. Banks and insurance companies on both sides of the Atlantic seem to agree that the risk attached to investing in jet aircraft under sound business principles is virtually non-existent. None of the purchasers seem to have any serious headaches in this respect.

Why should they have? Hitherto there has been universal complaining at general meetings and air transport conferences, and cries of woe were the fashion. All had trouble in financing even the most urgent depreciations, taxes and charges ate up profits, there was practically nothing left for interest payments on capital or for new investment, and it was a work of art to squeeze out even the most meagre dividends. All determinedly sang the same song. But then in December 1955 one airline operator stepped forward and painted quite a different picture to businessmen of his country: "Calculated on share capital and reserves, the gross profits of certain airlines before taxes in 1954 were as follows: T.W.A. 31%, United 23%, American Airlines 21%, P.A.A. 21% and even K.L.M. 8%."

This is by no means bad, even if these gross profits are reckoned before taxation. The airline bosses are no infants with their nine-figure balance sheets! They know as well as anyone how a taxation account must be prepared in order to prevent the worst. Between 31% gross profit and misery is a long step.

For once, then, there is no call for tears of sympathy. Nevertheless, there are many respects in which changes must be made. Another expert also said in December 1955 that the air transport market cannot under present conditions be affected by increased supply. Sales campaigns are not designed, as in the luxury trades, to create additional demand. The words "under present conditions" should be particularly noted. Present conditions can never be permanent, the third phase of air transport merely pushes them aside as out of date, and the new supply will give the air transport market a completely new face.

Jet transport

The third phase

By about 1960, then, four-jet aircraft with seating capacities for about 125 passengers—over 200 have already been ordered—will come into service. It has been calculated that the annual transport capacity of one of these aircraft equals that of a 45,000-ton ocean liner, i. e., that roughly 50,000 passengers can be carried by each aircraft in a year. Assuming that 60 of these aircraft, or roughly one third of the total, are used over the North Atlantic, this means that from about 1962 onwards some 3,000,000 seats will be offered. Assuming further that the economically minded operator bases his calculations on a 65% load factor, this still means that passenger volume will have to be multiplied by four or five between 1955 and 1962. Why not, though, if the air transport men know their business and attract new classes of passengers by reorganizing timetables, lowering rates and improving ground handling procedures, etc.? Why not, if the economic crisis which the Communist world prophesies for the "capitalistic countries" can be avoided? This, however, is not the concern of air transport, but exclusively of international politics.

Is it not a fascinating thought that by about 1960 a passenger will be able to board a trans-Atlantic aircraft in Paris or London at 07.00 local time and land in New York around 09.00 local time? In theory the same man could leave New York again the same evening, having completed his business—provided his health could stand it—and be back home at dawn ready for a new day in his office.

If this is not a revolution, what is? *EEH*

SUMMARY OF JET TRANSPORT ORDERS (As of February 15th, 1956)

	Buyer	Number	Total Cost U. S. $	Delivery Dates
A—BOEING 707 (three versions)	Pan American Airlines	20	109,000,000	Dec. 1958 to Nov. 1959
	American Airlines	30	135,000,000	from March 1959
	Braniff Airways	5	30,000,000	from Sept. 1959
	Continental Air Lines	4	21,300,000	1959
	Air France	10	71,000,000	Nov. 1959 to Nov. 1960
	Sabena	4	app. 20,000,000	from Dec. 1959
	Trans World Airlines	8+22[1]	app. 180,000,000	from April 1959
	Total	103	566,300,000	
B—DOUGLAS DC-8 (transcontinental and intercontinental versions)	Pan American Airlines	25[2]	160,000,000+	1959 to 1960
	United Air Lines	30	175,000,000	from May 1959
	National Airlines	6	36,000,000	1959 to 1960
	Eastern Air Lines	18+8[3]	165,000,000	May 1959 to March 1960
	KLM-Royal Dutch Airlines	8	50,000,000+	from March 1960
	Japan Air Lines	4	27,000,000+	1960
	Scandinavian Airlines System	7	app. 50,000,000	1960
	Pan American-Grace Airways	4	25,000,000	Early 1960
	Swissair	2	16,400,000	Spring-summer 1960
	Delta Airlines	6	app. 36,000,000	from June 1959
	Total	110+8	more than 740,400,000	
C—DE HAVILLAND *Comet IV*	B.O.A.C.	20	—	from 1958
D—SNCASE SE. 210 *Caravelle*	Air France	12	—	End 1958 to early 1960

[1] Hughes Tool Company, main shareholder in T.W.A., announced on February 7th, 1956 a firm order for eight Boeing 707-120 *Jet Stratoliners* for T.W.A.'s transcontinental services, and an option on another 22, the majority of which may be the 707-320 Intercontinental version. Cost (including spares) is estimated.

[2] Four of the 25 DC-8s ordered by P.A.A. are to be leased to Panair do Brasil.

[3] While "options to buy" are generally disregarded in this list, the option taken by Eastern Air Lines is listed here because the eight DC-8s involved may be regarded as forming part of a firm order.

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WORLD NETWORK FOR JET SERVICES

Interavia's map of world jet services gives a general guide, based on pure flying times, to the time saving that should be possible with the Boeing 707 and Douglas DC-8 after 1960–61.

In their present state, however, the airports indicated are a doubtful factor, particularly as regards runway lengths. The only airports today with runways long enough for these four-jet long-range aircraft are London, New York, Leopoldville and Buenos Aires. No doubt many other world air transport centres will have been extended by 1960.

The map also still contains a vast area where no routes are marked; no world services as yet pass through the centre of eastern Europe and Asia. Nevertheless, the picture emerging is a fascinating one. London–New York non-stop in 6 hrs. 10 mins.; Paris–New York non-stop in 6 hrs. 25 mins.; Paris–Rio de Janeiro with one stop at Dakar, actual flying time 10. hrs 05 mins.; New York–Los Angeles non-stop in 4 hrs. 20 mins.; New York–Rio de Janeiro non-stop in 8 hrs. 45 mins. The Stockholm–Los Angeles Arctic route could be covered in 10 hrs. 10 mins. flying time. with a single call at Söndre Strömfjord.

Turbine Transport Experience

BY SIR MILES THOMAS, D.F.C.,
CHAIRMAN OF BRITISH OVERSEAS AIRWAYS CORPORATION, LONDON

The Editors are pleased to have among their authors the head of the only airline which to date has had an opportunity of gathering large-scale practical operational experience with jet transport aircraft—British Overseas Airways Corporation. While British jet services have been suspended for some time owing to circumstances beyond B.O.A.C.'s control, the airline is planning to resume them again on its Empire routes in 1958–59. -Ed.-

Airlines throughout the world are nowadays thinking in terms of pure jet and turboprop equipment, the volume of orders for aircraft of these types is rapidly increasing, and during the next few years many operators will be changing over from piston-engined aeroplanes on long distance as well as on medium stage routes.

As the first international airline to have offered the public smooth and swift travel in pure jet airliners, B.O.A.C. has accumulated an invaluable fund of practical experience in commercial jet operation. Between May 1952 and April 1954 we flew more than 25,000 *Comet* hours on regular services and carried nearly 55,000 passengers. Revenue passenger miles amounted to 208,642,935.

B.O.A.C. will also be the first airline to introduce turboprop airliners on long distance routes when the Bristol *Britannia* comes into service later this year. Members of the Corporation flying staff have already spent many months assisting in the manufacturer's development programme of this extremely promising aircraft, thereby acquiring highly useful knowledge of the *Britannia's* operational characteristics.

Our experience has shown us that there is nothing mystical about the operation of jet aircraft. Although they demand the application of some new techniques they do not present any great problems or require undue cosseting.

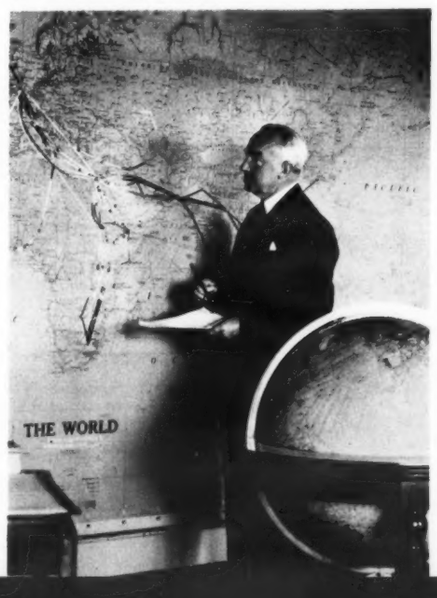
Before the introduction of the Series One *Comet,* the only previous operational experience of jet propulsion in Britain was with single and twin-engined fighters which were not called upon to display the handling and comfort characteristics demanded of an airliner which carries fare-paying passengers. In fact, we were introducing a four-engined airliner with the performance of the pre-supersonic jet fighter. This was undoubtedly the most significant development in civil air transport to that date and we were proud of the pioneering role we had elected to play by our decision, soon after the last war, to place the first airline orders for jetliners.

A *Comet* was made available to B.O.A.C. by the Ministry of Supply early in 1951 and in advance of the first deliveries. We were thus able to undertake a programme of development flying during which it was soon discovered that the actual handling of the aircraft was a straightforward matter and that the emphasis of our research was to be on the technique of operation. Naturally, a cruising speed approaching 500 m. p. h. demanded faster mental activity by the captain and crew than was required of them when they were flying piston-engined aircraft. Decisions had to be made more quickly, and everyone had to accustom himself to thinking one step ahead all the time.

There was a certain increase in the tempo of the work to be done on the flight deck because everyone had to do the same work in a shorter period of time. However, we found that it was possible to streamline various procedures and to eliminate some of the tasks hitherto carried out in flight on piston-engined airliners, and so reduce some of the effects of this increased tempo. In this context it is worth noting that the conversion of crew members to jets showed that the age of the flying staff was largely immaterial provided that they were not too conservative in their approach to flying.

Navigation is a good example of the impact of high cruising speed on flight deck procedures. Obviously the officer responsible for the navigation on a *Comet* had to make his calculations with a new alacrity. To offset this, however, the *Comet* cruised for the larger part of its flight above weather and at heights where the navigation devices worked particularly well. One procedure which needed amendment, however, was the practice of reporting by radio at pre-determined positions to air traffic control centres, particularly in areas of high traffic density. The airways reporting points were designed for aircraft travelling at piston engine speeds, so that an aircraft cruising between 450 and 500 m. p. h. had to radio position reports at extremely short time intervals. This was considered unacceptable, and by agreement with the various air traffic control authorities it was arranged that the *Comets* need only report at a smaller number of designated points.

Sir Miles Thomas, D.F.C.



Another example of the re-planning of work on the flight deck arose in connection with the duties of the flight engineer, with particular relation to the consumption of fuel. It was necessary to integrate the weight of fuel used as against distance flown with a high degree of accuracy, and conventional fuel gauges were not sufficiently precise for this exercise. Instead, the engineer watched flow meters and kept a careful log of the rate of fuel flow. Periodically this was checked against a form of the well-known "How Goes It", to ensure that the distance covered corresponded to the amount of fuel used. The engineer's work was eased in other directions, however, by a reduction of the entries required in engine logs, and the simplicity of the engine and ancillary control.

The actual cruising procedure in the *Comet* was simplified compared with piston-engined airliners in that the pattern for the cruise allowed little variation. After take-off the *Comet* would climb for the first half-an-hour or so of its journey to the most economical cruising altitude for its weight, about 35,000 feet. The cruise itself was a very gradual climb at constant r. p. m. as the weight of the aircraft was reduced by the consumption of fuel. The descent was begun at a point some 150 miles from the airport of destination.

Before the introduction of the *Comet* there was a feeling in some circles that jet airliners would present air traffic control problems where there was "stacking" at airports because of their rate of fuel consumption at lower altitudes. We worked on the principle that B.O.A.C. would seek no special favours for the *Comet* from control authorities and in practice it was found that holding consumptions were not as high as some people originally anticipated and that "stacking" was practicable. It was desirable that advance notice of the possibility of diversion or a "stand-off" period should be given to the *Comet* before the descent began but in

Comet III, forerunner of *Comet IV*, with which B.O.A.C. expects to resume its jet services in 1958.

general the aircraft proved itself to be not inflexible when operating in and out of airports. Fuel was always carried for wave-off diversions.

The great value of flight simulation for training purposes was clearly demonstrated by the *Comets* and it was found that after crew members had carried out exercises on the simulator they reached a degree of proficiency after only one trip "down the route" whereas two or three trips would have been necessary without the simulator experience. Because of the lack of noise and vibration on the flight deck and because times in the air on any given sector were so drastically reduced compared with piston-engined flight times, the crew members experienced less bodily fatigue despite the whole-hearted concentration required in the performance of their duties. Incidentally, the lack of vibration throughout the airframe also resulted in a noticeably longer life for many of the components.

Although our experience of flying the *Britannia* is not yet comparable with that achieved with *Comets,* I can say that there do not appear to be any outstanding problems or difficulties associated with the introduction of long range turboprop airliners. Because the *Britannia* will fly neither as high nor as fast as the *Comet* the operating techniques are more nearly akin to those of piston-engined aircraft. The normal operating altitude for the *Britannia* will be between 20,000 feet and 30,000 feet according to weight, sector and other considerations, and it will cruise at constant compressor revolutions. In order to comply with air traffic control requirements it will make a "stepped cruise", rising, say, 2,000 feet every two hours on flights of more than about 1,000 miles.

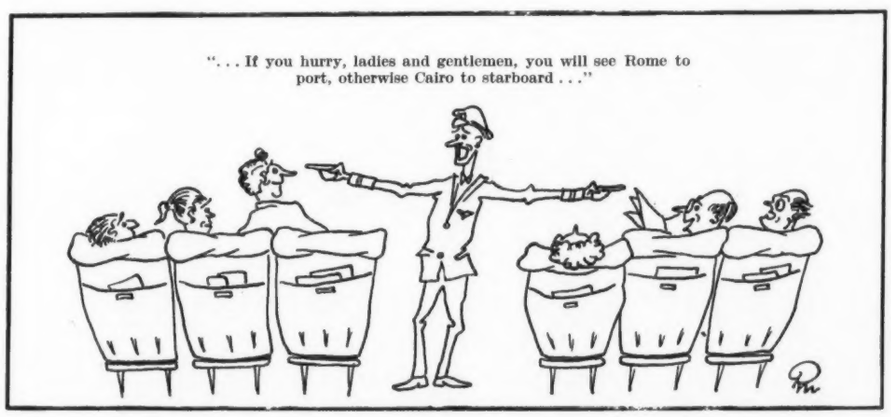
Although the *Britannia* is slower than the *Comet,* it is that much faster than piston-engined machines for the same question of rapidity of airways reporting points to arise, and we anticipate that, as with the *Comet,* a new reporting procedure will have to be applied. Like the *Comet,* the *Britannia,* when about to take off, will receive clearance to start from the apron instead of waiting at "run up points" before moving forward to the runway. This is to avoid wasteful fuel consumption on the ground and also because turbine engines do not require the test runs associated with piston engines before take-off. Such a procedure, of course, does not enable jets and turboprops to "jump the queue" when a number of aircraft are taking off in quick succession; they merely await their turn on the apron and then move straight out for take-off.

In our experience the turbine engine gives a high standard of serviceability, with the result that there are fewer delays through engine trouble. Landing and take-off runs have not given rise to any particular problems, and on its recent round-the-world flight the *Comet III* produced some convincing evidence of its ability to make a quick take-off and to use a short landing run. Our *Britannias* are flying to what are probably the most stringent requirements to be laid down for take-offs and landings. The *Proteus* turbine engines have a big power reserve at low altitudes, and the *Britannia's* take-off performance on three engines in the event of an engine failure is magnificent.

Not unnaturally, there is some public concern about the noise of jet airliners at airfields near large centres of population. This question does not arise with the *Britannia;* in fact the exact reverse is the case, for this aeroplane has justly earned itself the sobriquet of "the whispering giant". It remains to be seen what can be done to subdue the powerful roar of pure jet engines, but there are hopeful indications that a solution to this particular problem may be forthcoming within the comparatively near future. It is indeed a problem which has to be tackled with much vigour, for clearly it would be wrong to transport passengers from one end of the globe to the other at high speeds and in great comfort if to do so were at the expense of the nervous health and civilised amenities of thousands of people living within earshot of the major airports of the world.

Meanwhile, it is important from the point of view of the airline and passenger that time saved in the air should not be wasted on the ground. For this reason we found that it was necessary to streamline ground procedures at stop-over points on the *Comet* routes, so that refuelling, loading and unloading cargo and catering supplies, and all the other tasks, should be compressed within the shortest possible space of time. This can be accomplished by careful planning and the effective training of ground staff, and in our experience it was possible to reduce transit times by as much as a quarter. Another feature of high speed flight, especially when flying due east or due west, is the rapidity with which the aircraft moves from one time zone another. It certainly raises a problem in the serving of meals and brings into our calculations yet a third time scale, which must be taken into account in the interests of the comfort and welfare of the passengers: G. M. T., local time—and "tummy time".

It is not possible within the scope of an article of this kind to cover every aspect of jet and turboprop operation but I have mentioned various important considerations which arise when introducing this new type of equipment and have given some indication of the work involved. In summing up, I would say that perhaps the most important point which has emerged from B.O.A.C.'s experience is that the pure jets and turboprops which are revolutionising air travel in terms of speed, comfort and economy can be smoothly integrated into the comprehensive pattern of airline operations.



Jet transport

Will the Airlines be able to Operate their Intercontinental Jet Transports?

By Raymond Dupré, Assistant Managing Director, Air France, Former Chairman of I. A. T. A.'s Technical Committee

The story of commercial transports during the past ten years has been primarily one of developing piston engines. The installation of more and more powerful engines in aircraft whose general aerodynamic design was improved only in details, most of them aimed at facilitating take-off and landing operations, enabled advances to be made in performance, while remaining well below the speed region where compressibility phenomena become troublesome. The last major progress was the introduction of the compound engine, whose lower specific consumption provided increased range and made it possible to consider non-stop West-East flights across the Atlantic. Unfortunately the improved performance has not brought any notable reduction in direct operating costs.

Now long-range jet transports—the Boeing 707 and Douglas DC-8—have come on to the market and will be in service on the commercial routes from 1959 onwards. These are aircraft weighing 125 tons and more, capable of carrying payloads of some 15 tons over ranges of 3,700 miles. Their novelty is that, according to calculations, their cost per seat-mile under ideal operating conditions, at altitudes of around 35,000 ft., may be expected to be markedly lower than that of conventional piston-engined aircraft within a wide range of stage lengths.

The improved transport conditions offered customers and the reduced fares made possible by lower operating costs will attract a constantly growing number of passengers, thus enabling the considerable new transport potential to be used to the best advantage.

Can ground developments keep pace?

But for these optimistic forecasts to be translated into reality, the new aircraft must be properly operated, i. e., under conditions best meeting their needs. At the present time, however, it must be admitted that aircraft developments are ahead of transport developments, and there is no longer any common denominator between advances in aircraft design and those in ground organization. This is an alarming situation which will have to be remedied.

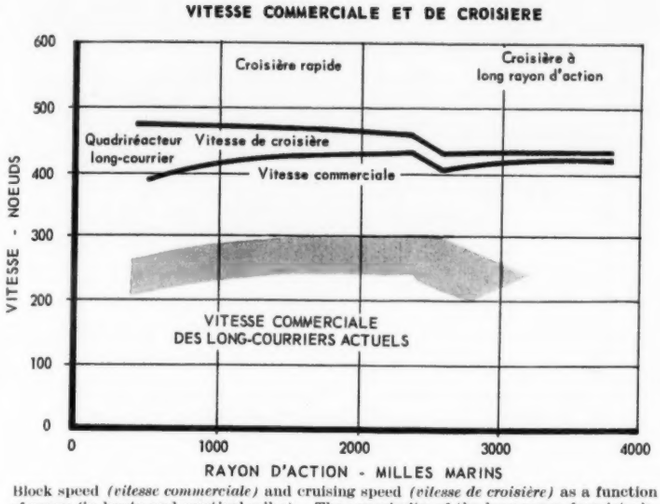
Incidentally, this is the main theme of all international aeronautical meetings, of all recent communiqués from the highest authorities in the air transport world. At I.A.T.A.'s last General Meeting in New York, the airlines' leading technical experts stated that the ground organization, on which all are entirely dependent, is five years behind aircraft development. By the time jet transports come into service, it looks as if the ground organization may have ten years to catch up, unless a special effort is made to develop ground facilities at the same rate as aircraft.

This anxiety is wide-spread. Lieutenant General Joseph Smith of the U.S. Military Air Transport Service recently echoed it. Air transport, he said in substance, depends on a complex but homogeneous system of aircraft, personnel, airports, meteorological services, telecommunications, navigation aids, procedures, maintenance methods and organization. The whole system should grow and develop in harmony with the aircraft, which should not be allowed to get "out of step" with its environment.

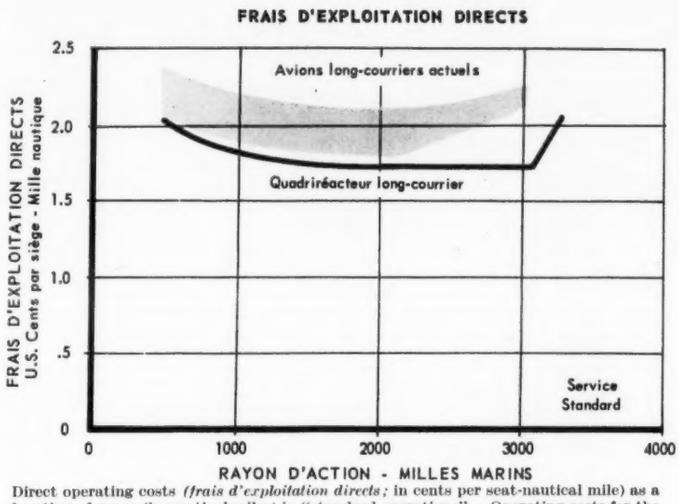
Such lack of coordination is costly. Delays due to the traffic control system, flights made at unfavourable altitudes because of congestion on airways at the optimum altitude, detours and stacking that could be avoided with better landing aids, inadequate runways which prevent aircraft from being used at their maximum weight, errors or inadequacies in weather forecasts and the considerable fuel reserves that have to be carried as a result, the necessity of running to inconvenient timetables because certain routes are saturated during the peak hours, all result in losses of payload and bad utilization of aircraft on the one hand, and in higher costs for fuel, maintenance and personnel on the other. Then there is the effect on customers, who in some cases abandon air transport or are at least not attracted to it.

If nothing is done to adapt the ground organization to the aircraft, if the present gap in development is allowed to grow, the improvements in operating conditions and in costs which can be expected from the new generation of transports may be reduced to zero. It is therefore essential that ground engineering catch up with aircraft engineering. This is an important task and can suffer no postponement. It is too often forgotten that it is not enough

The author (with sun glasses) in the co-pilot's seat of the Boeing 707 prototype. Next to him (with headphones) Boeing test pilot R. L. Loesch and Air France President Max Hymans.



Block speed *(vitesse commerciale)* and cruising speed *(vitesse de croisière)* as a function of range (in knots and nautical miles). – The superiority of the long-range four-jet aircraft *(quadriréacteurs long-courriers)* over conventional models *(long-courriers actuels)* is clearly discernible. The jet transport could cross the North Atlantic non-stop even in the East-West direction.



Direct operating costs *(frais d'exploitation directs;* in cents per seat-nautical mile) as a function of range (in nautical miles) in "standard operations". – Operating costs for the long-range four-jet transports *(quadriréacteurs long-courriers)* are noticeably lower than those of present long-range aircraft *(avions long-courriers actuels)*.

merely to find the theoretical answer to the problems. There is a long delay between the design of facilities and their installation in adequate numbers and reliable form. These delays are even more serious because in the interval the airlines will find that, to ensure rational operation of their aircraft with their constantly increasing performance, their requirements will have grown still more imperative.

Flight planning

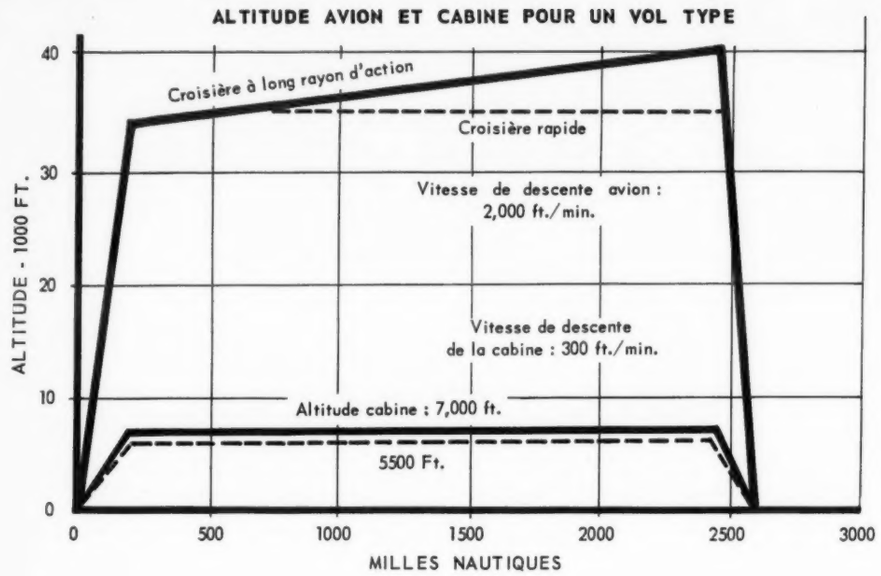
The marked increase in aircraft weight and speed and the attendant increase in power and fuel consumption necessitate greater accuracy than before in the planning of a flight. The jet engine is at a disadvantage at low altitudes, where its specific consumption is high; the high altitudes at which the new aircraft will operate are those where the winds are strongest and where meteorological forecasts are the most likely to be unreliable because of the relative lack of information on these altitudes. This deficiency must be made good if operations are not to be penalized by the need to carry substantial fuel reserves.

Most operators carry a cruising fuel reserve to allow for errors in wind forecasts. A frequent mistake here is the belief that fast aircraft are less sensitive to wind changes, as regards fuel reserves, than slower ones. True, a difference of 50 knots in a head wind means an extra two hours over a stage of 2,000 miles for an aircraft whose mean speed is 250 knots, but only 33 minutes for an aircraft with an average speed of 450 knots. However, if the former is a conventional piston-engine aircraft with an hourly consumption of 3,000 lbs. of gasoline, while the second is a jet transport which consumes 12,000 lbs. of kerosene per hour, the extra consumption needed in both cases to meet the same difference in wind force is roughly the same. Nevertheless the advantage remains with the large aircraft, since its loss in payload is relatively smaller, provided, of course, that errors in wind forecasts at high altitude are not greater than in those for the altitudes now used.

Here it should be stressed how important it is to calculate fuel reserves accurately, since excessive reserves penalize operations, the specific range being immediately affected by weight. Even in jet aircraft with a gross weight of around 50 tons and a specific range in optimum flying conditions of 0.06 miles per lb. of fuel at maximum weight and 0.09 miles per lb. for a gross weight of 35 tons, an extra 3,300 lbs. on the fuel reserves on arrival reduces the range by 280 miles for the same fuel consumption—in this example 15 tons—if take-off weight is limited. In the case where take-off weight is not limited, consumption for the full range will increase by 1,650 lbs. This means that in order to carry a given reserve, consumption will rise by half the reserve. The situation will probably be even more critical in heavy jet aircraft, and it is quite possible that in certain conditions the extra fuel consumed will be equal or nearly equal to the reserve carried, so that payload is sacrificed for nothing.

Up to the present the influence of temperature on cruising performance has been ignored, at any rate for piston-engine aircraft. Even now, in certain flight phases, such as climb, and for certain aircraft whose consump-

Forecast of Boeing 707-320 *Intercontinental Stratoliner* operations: up to 122 first-class or 147 tourist-class passengers would regularly be carried non-stop across the Atlantic and other extra long stages by Air France, Sabena and P.A.A. Passengers enter the aircraft via two large doors in the port side of the fuselage, while supplies for the flight are loaded through two smaller doors on the starboard side.



Cruising altitudes and cabin pressure altitudes (in feet) of the future four-jet transports. Cruising altitudes will be between 33,000 and 40,000 feet, i. e., in a region for which only sparse meteorological information has hitherto been available. To economize fuel it will also be advisable to fly at a constantly increasing altitude as weight decreases *(croisière à long rayon d'action)* or to "jump" in several stages from the initial to the final cruising altitude. This method presupposes an improvement in air traffic control systems. – While the aircraft descends at a rate of 2,000 ft./min., cabin pressure altitude must be reduced by the equivalent of not more than 300 ft./min. to ensure passenger comfort.

tion per mile varies markedly with the density of the air, such as those fitted with compound engines, this practice is difficult to justify. It becomes unacceptable when we have to deal with jet aircraft.

Flight planning necessitates a reasonably accurate knowledge of the temperatures that will be encountered en route. Despite urgent recommendations by I.C.A.O., some of them dating from 1950, little progress has been made in this direction. The number of radiosonde measurements made at altitude is too small to provide a sufficiently accurate picture of temperatures. Here too safety margins will have to be allowed. The problem is further complicated by the fact that inaccuracies in wind and temperature forecasts are not independent of one another, nor are their effects on cruising performance.

Here the question of jet streams deserves attention, and it is to be hoped that they will be investigated further to enable systematic advantage to be taken of them wherever possible.

The problem is a different one and more crucial when it comes to forecasts for terminal areas, as concerns both preparation and execution of flights. This is obviously due to the jets' high consumption at low altitudes, so that wherever possible detours must be decided upon before the aircraft descends below a certain altitude. The following figures have been quoted for the *Comet:* a given quantity of fuel permitted a detour of 620 miles in normal cruise conditions, but only 410 miles if the aircraft descended towards the original airport of destination and then climbed again to fly to an alternate airport. Investigations now in progress on the new long-range jet transports will undoubtedly produce the same results.

The air traffic problem

A glance at the aeronautical trade press gives some indication of the problems raised by congestion on the airways in the United States, where constant efforts are made to draw the authorities' attention to them. What is happening in the United States is not a purely local phenomenon; it also applies to the North Atlantic. It may seem strange that such a wide expanse should be congested, but the trouble is that all airlines try to operate along the most favourable routes as regards wind and at the optimum altitudes, which considerably cuts down the space used by aircraft flying the Atlantic at any given time. To reduce congestion, military operators, who provide a substantial proportion of total traffic, have agreed to plan their flights for the civil operators' "off-peak" periods; they use lower separation standards than those recommended by I.C.A.O. and have greatly reduced their utilization of VHF facilities in favour of UHF and cut the volume of air-to-surface communications. Airlines in turn re-examine the situation periodically and take such measures as they can to improve it. But these are merely palliatives and will be inadequate in a few years' time. The number of aircraft is unlikely to fall despite the jet transport's substantial increase in transport capacity. On the contrary, traffic seems likely to grow in at least the same proportion.

The ease of access to the podded engines in the Boeing 707 and Douglas DC-8 also reduces "dead time" on the ground.

It is generally estimated that it will have increased by about 50% on the North Atlantic by 1960. During this time aircraft speeds will also increase, which will not simplify the problem. Finally, the best flight plan for a jet aircraft in cruise is a progressive climb, with altitude increasing as the aircraft loses weight. Any marked departure from the optimum altitude increases consumption. This limitation did not greatly hamper the *Comets,* which were the only commercial aircraft flying above 25,000 ft., but the problem will have to be solved in the future. Either the whole idea of vertical separation between aircraft flying at constant levels will have to be abandoned, or an exact system of horizontal separation worked out to permit of successive flights at increasing altitude. Before this is possible, existing navigation facilities will have to be improved, discipline among operators tightened up, control facilities installed and new standards of horizontal separation worked out on a basis of distance between aircraft or time elapsed. This will be the only way to organize operations by aircraft of similar weight all seeking the same altitudes to a greater degree than at present when the only factor determining the choice of altitude is the desire to find the most favourable wind and not the need to fly at the high altitude providing the best consumption figure. New navigation methods are appearing, such as inertial navigation, but it would be wrong to expect them, however accurate they may be, to solve the problem alone. For one thing, they may not come into service in time; for another, the main solution must be sought in the field of air traffic control procedures and facilities.

I.A.T.A. member companies have devoted considerable effort during the past few years to the study of traffic problems in terminal areas, approach and landing. Much progress remains to be made in this field if irregularity or a marked increase in flight time is to be avoided. It has been calculated that the cost of one hour's unproductive flight by today's aircraft is already $ 1,000, and this figure will inevitably increase in view of the tonnage of future four-engined transports. It is easy to see how deficient the ground organization is

when this figure is multiplied by the number of aircraft in service and the frequency of delays due to one reason or another. Even if the unproductive flight time does not exceed two percent of the aircraft's total utilization the loss thus incurred amounts to several million dollars every year, not counting the losses, substantial but difficult to evaluate, due to the reduction in utilization. A recent I.A.T.A. meeting calculated the losses sustained by an airline through inefficient navigation aids or control services. Figures were based on a hypothetical airline operating ten modern aircraft across the North Atlantic at a frequency of 113 flights per month, assuming on the one hand that each round trip involves 50 minutes of unproductive flying because of deficiencies in navigation services and facilities, and on the other that fuel reserves could be reduced by an amount corresponding to half an hour of flight if the services and facilities were fully efficient. Under these conditions and allowing for the loss due to unproductive flying time and decrease in payload as well as the increase in direct operating costs, the total annual loss can be estimated at $ 2,235,000.

The commercial jets will not be alone in the air

Today's commercial air transport is limited to an altitude of 25,000 ft., while military aircraft, i. e., interceptors and bombers, fly at 35,000 ft. or higher. However, there is already a problem of coordination, acute in certain parts of the world, in particular in Western Europe where a Committee of European Air Space Coordination has been formed within N.A.T.O. It is obvious that the introduction of commercial aircraft flying at altitudes where military aircraft are practically alone today will make closer coordination absolutely essential and that certain procedures such as the penetration of military jet aircraft flying by radar into civil air routes will have to be thoroughly investigated.

This same kind of difficulty will obviously be met again in the vicinity of airports, where both piston-engined aircraft and jet aircraft for many years to come will have to operate in the same air space. Here too, in order to avoid the chaos resulting from a constant increase in traffic and a growing diversity in aircraft characteristics, the preparation of a high capacity air traffic control system in airport regions is urgently needed.

Airports—runways and services

Only a few months ago operators considered that runways with a length of approximately 8,000 ft. were the maximum needed in the commercial field. However, the new generation of long-range four-jet transports, when fully loaded, will need runway lengths of the order of 10,000 ft.; though the mean weight of aircraft in flight is well matched to their jet engines' cruising thrust, the thrust available for take-off is inadequate, hence the need for runway lengths which would otherwise have been described a few years ago as prohibitive.

With their weight of more than 100 tons, four-jet transports will obviously need runways with a high mechanical resistance. Among the twelve major cities in the United States likely to be served by jet aircraft in 1960 only half today have runways that are adequate to accommodate them.

Considering only the dimensions aspect of runways, the present lengths of 6,500 to 8,000 ft. will be sufficient for take-off and landing on medium or short stages, since the take-off distance of jet aircraft varies considerably with their weight. The essential problem will therefore arise in connection with take-off on long stages where the aircraft is likely to take off at a weight in the neighbourhood of its maximum.

Whether it is one of reinforcing or of lengthening runways, the problem must be solved without delay, since in this field the time elapsing between planning and final realization is frequently considerable.

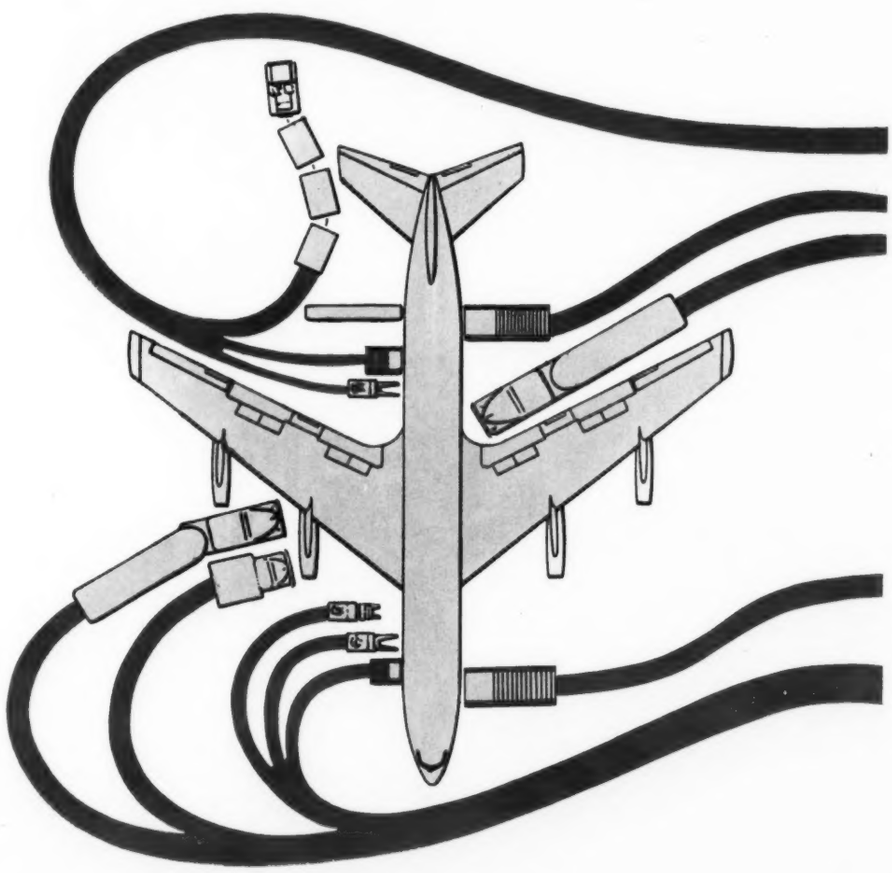
The essential defects of many present airports is that they cannot handle aircraft movements sufficiently fast and thus involve aircraft in substantial waiting periods on the ground with the attendant inconveniences falling upon passengers. This defect can only get more serious if nothing is done to remedy it before the introduction of very fast aircraft with a large capacity for both fuel and passengers.

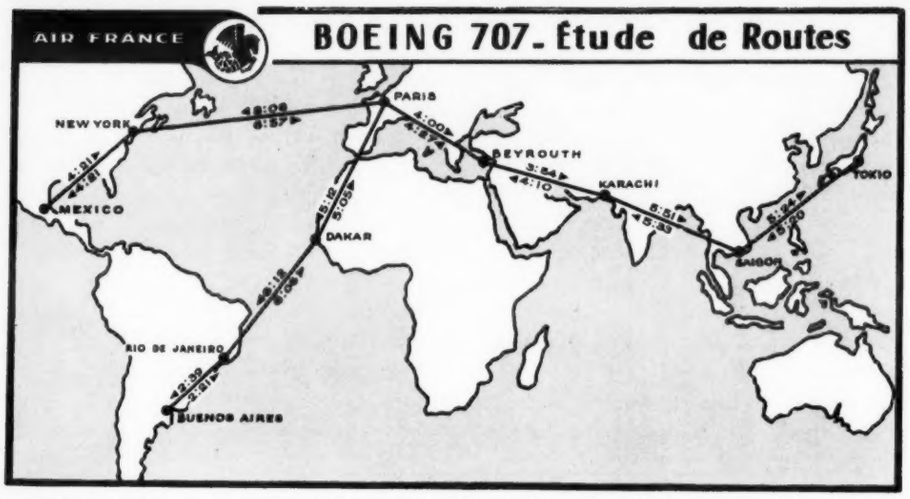
The effect of waiting periods on the ground naturally becomes more serious as the aircraft's average speed increases. For example on the Paris-Tokyo route in a Boeing 707 (average speed nearly 500 m.p.h.) commercial speed would be 425 m.p.h. with allowance for three stops of one hour each at Beirut, Karachi and Saigon, but would fall to 400 m.p.h. with three stops of 1 ½ hours each and to 375 m.p.h. with three stops of 2 hours each.

The amount of time spent on the ground, both during intermediate landings and during maintenance and overhaul, depends on the design of the aircraft. Very definite progress appears to have been made in this direction by increasing the number of access points, making them easier to reach and arranging

A rational arrangement of freight doors, refuelling and maintenance points etc. can appreciably cut down ground time at intermediate landings *(opérations de piste)*.

OPERATIONS DE PISTE





Preliminary proposals for an Air France jet route network: the whole world is at the passenger's doorstep. With the shorter flying time the closer arrangement of seats in the tourist class should not be too disturbing, so that aircraft will be able to carry far more passengers on every flight than ever before.

them in such a way that they can be used simultaneously. For example "podded" jets are easy of access, and under-wing fuelling can be accomplished at a rate of 800 gallons per minute, which should enable refuelling to be completed in the majority of cases in a maximum of 20 minutes if ground equipment is adequate.

The design of airport installations also has an important effect on time spent on the ground during intermediate landings. Some of the secondary problems are easy to solve, such as provision of a hydrant fuelling system, a distribution system for distilled water (four-jet transports can use as much as 600 gallons for take-off in hot weather), for electric power etc. But it suffices to time the embarkation and disembarkation of passengers to realize that tremendous progress must still be made if the time spent at airports and between airports and cities is not to exceed 50% of the total time needed to cross the Atlantic. This point should not be ignored when, in order to reduce wear on the parking area or non-concrete taxiways due either to the jet exhaust or to fuel leakages, or merely to save fuel, plans are made to tow the aircraft to the take-off runway before starting up the jet engines.

The increase in aircraft capacity should not result in a reduction in the number of aircraft movements if the forecasts of increased traffic prove to be correct. On the contrary, each aircraft movement will involve the carriage of a larger number of passengers, with the risk of holdup unless most of the existing installations are improved and the interminable and frequently pointless customs, police and other checks simplified. During a baggage examination lasting twenty minutes a distance of 200 miles could be covered!

The problem of noise

There has been much talk during recent years on the problem of noise. Obviously, as one of the attorneys in the recent case at Cedarhurst, Long Island, pointed out, it is extremely important for airport managements and airlines to conduct their operations in such a way as to cause minimum nuisance to local residents, leaving aside all legal considerations. Take-off directions are already chosen wherever possible to avoid flying over residential areas at low altitudes, and climb and descent procedures have been speeded up. Up to the present, however, little or nothing has been done to reduce noise at its source, namely the engine. Jet engines are noisier than piston engines. It is therefore essential that some means of reducing their noise at the source should be perfected, rather than merely making the inside of the cabin quieter. As a matter of fact, since certain managements have threatened to close their airports to jet transports, astonishing progress has been made, and the manufacturers are testing a number of different silencing devices. Reports on this subject, however, are frequently contradictory, and manufacturers must continue to give this point their full attention.

Airlines too must make an effort

The full effect of reduced costs cannot be obtained unless the airlines get the best out of their jet transports, firstly by endeavouring to improve utilization through reducing non-productive time and overhaul and maintenance delays. They will then have to find the customers to fill these magnificent aircraft, each of which will be able to carry 50,000 persons from one side of the Atlantic to the other every year, or roughly the same number as a 45,000-ton ocean liner.

A great deal has been done since the first aircraft fitted with a turbine engine by Henri Coanda took to the air at Issy-les-Moulineaux in 1910, and the rate of progress achieved has itself constantly risen. It is for this reason that the problems raised by the introduction of four-jet transports of the Boeing 707 and Douglas DC-8 class are not problems for tomorrow but for today, and that we must already begin to think about the generation of aircraft which will succeed them.

All these problems will, of course, also be encountered in the *Caravelle* medium-stage twin-jet transport, of which Air France has recently ordered twelve. However, the SE.210 *Caravelle* needs only 6,070 ft. for take-off and 3,770 ft. for landing, which will enable it to use practically all existing runways at major airports.

What does the future hold?

In the years immediately following their introduction into service, the present jets cannot be expected substantially to increase their speeds by employing more powerful engines because of the compressibility limitations which will rapidly intervene.

An increase in power will improve take-off conditions on long-range flights and should enable savings to be made by cruising at high altitudes.

It is also possible that the development of by-pass jets will reduce specific consumption, which would result in appreciable savings.

However, we shall have to wait for a new generation of aircraft before much progress can be made in speed. As has frequently been noted, such progress has always been made in steps rather than continuously. This will certainly be true in the future, since in order to be faster the future generation of aircraft will have to be supersonic, that is to say, they will be the result of much more advanced aerodynamic and thermodynamic engineering. The rate of progress in aeronautical engineering suggests, however, that the advent of such long-range aircraft is not far distant. This is a further reason for examining the problems raised by the introduction of the first long-range four-jet commercial transports and for endeavouring to find in good time the solutions needed to ensure the safety, efficiency and economy of their operation.

The prototype of the Boeing *Stratoliner* jet transport coming in to land. All four landing flaps (underneath the wing) and the four spoilers that act as air brakes (on top of the wing) are deflected; the outer ailerons (locked during high-speed flight) and centre ailerons also come into operation.

The Coming Jet Transport Fleet

BY INTERAVIA STUDY GROUP

Three range scales, three sizes

It has been repeatedly stressed in these pages[1] that recent developments in aircraft engineering have invalidated the usual definitions of short, medium and long-distance aircraft. In particular, the substantial lengthening of the medium stages has been pointed out, as has the decisive importance of the non-stop stage between London and New York (3,000 nautical miles) and between Paris and New York (3,160 nautical miles) in the increasingly dense North Atlantic traffic. The scale of block distances therefore no longer holds good, and a revised scale, as follows, is needed to provide a reliable basis for a technical examination of the future air fleet.

I — Short stages:	0— 500 n. miles
II — Medium stages:	500—1,500 n. miles
III — Normal long stages:	1,500—3,000 n. miles
IV — Extra long stages	over 3,000 n. miles

As will be seen, the classification is based on round figures in nautical miles, the only measure of length common to both the Anglo-Saxon and the metric systems. A nautical mile measures 6,080 feet. In addition, the great circle distance between London and New York (3,000 nautical miles) marks the limit between "normal" and "extra" long stages.

There seems to be little point in defining an upper limit for extra long stages, though the longest block distances at present of commercial interest in international air transport, such as Seattle-Tokyo (4,150 nautical miles) or Honolulu-Auckland (3,800 nautical miles), need only aircraft with a still air range of roughly 4,400 nautical miles, with full fuel reserves available for detours and stacking. The relationship between these and other standard routes chosen as examples and the above-mentioned range scales is shown in *diagram II*.

Obviously, since they must operate at high altitudes, jet transports are scarcely likely to play any part in short-stage traffic, which will be left to "conventional" aircraft of all sizes (with piston engines or propeller turbines) and to helicopters and convertible aircraft.

For each of the other three range scales there are special aircraft designs under discussion today (cf. *diagram I*).

Medium stages: S.N.C.A.S.E. *Caravelle*

Normal long stages: de Havilland *Comet* (and the transcontinental versions of the Boeing *Stratoliner* and Douglas DC-8)

Extra long stages: Boeing *Intercontinental Stratoliner;* Douglas *Intercontinental DC-8.*

How the payload-range characteristics of these designs fit into the range scales is also shown in *diagram II*. The roughly 100% higher payload capacity of the two American solutions compared with the European is clearly discernible.

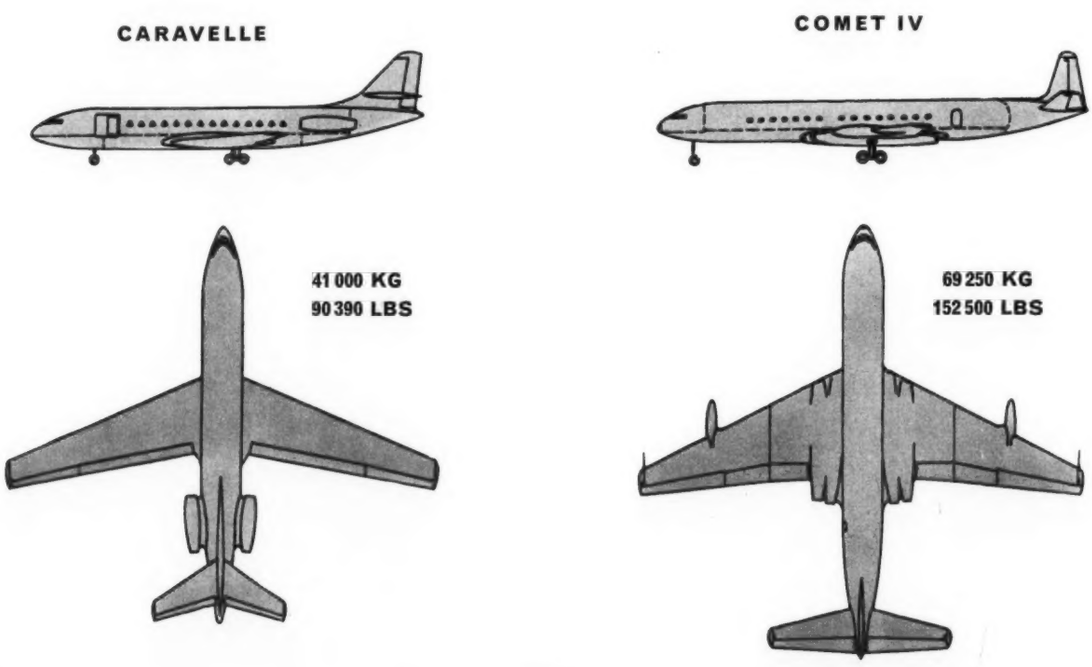
*

What is the reason for these differences? Here it must be remembered that the four manufacturers who have so far developed commercial jet transports from the beginning have worked with very definite—and different—stage lengths and traffic volumes in mind, setting out to provide the greatest technical suitability and economy in the aircraft they offer for their specific tasks.

● *Caravelle size class:* In designing their twin-jet SE.210 *Caravelle,* the French Government-owned firm of S.N.C.A. du Sud-Est were thinking primarily of future high-speed services in the Europe-Mediterranean-North Africa region, i. e., on routes such as Paris-Casablanca, Paris-Cairo, Paris-Moscow. The *Caravelle* was therefore laid out for existing

[1] Cf. *Interavia* No. 10, 1955, p. 764 and No. 12, 1955, p. 911.

Diagram I: Comparative size and shape of the twin-jet S.N.C.A.S.E. *Caravelle* (for medium stages) and the four-jet de Havilland *Comet IV* (for normal long stages) with . . .



airport runways and could be "built round" existing jet engines. There was thus no need to demand airport extensions or to wait for more powerful "super engines." According to the manufacturers, the *Caravelle* reaches its lowest operating costs (35 French francs per tonne-km) on stages of around 1,000 nautical miles and is thus a clear example of a *new-style medium-stage aircraft*. Its seating capacity (70/91 passengers) should be ample for the high-speed transport volume likely to be available in the Europe-North Africa region in the near future.

● *Comet size class:* The British firm of de Havilland, however, designed the *Comet IV* and its predecessors (Marks I, Ia and II) for the somewhat longer standard stages on B.O.A.C.'s Commonwealth routes to South Africa and Australasia. Block distances such as London-Tripoli (1,280 nautical miles) and Tripoli-Kano (Nigeria: 1,265 nautical miles), and the slightly longer stages to the Far East (London-Cairo = 2,040 nautical miles; Cairo-Bombay = 2,350 nautical miles; Bombay-Singapore = 2,130 nautical miles) will be the *Comet IVs'* main stages when B.O.A.C. puts them into service in 1958. The *Comet IV* is said to reach its lowest operating costs for the 76-seat tourist version (14.2 pence per ton-mile) at 2,300 nautical miles, and for the 58-seat standard version (16.5 pence per ton-mile) at 2,500 nautical miles. Hence it is an *aircraft for normal long stages*. Its seating capacity seems to be in line with the traffic volume expected. In addition, the *Comet IV* will have the same jet engines (Rolls-Royce *Avon RA.29s*), already fully proven and known in every detail, as the *Caravelle*. It will be able, as the *Comet III* prototype's round-the-world flight in December 1955 proved, to use existing runways.

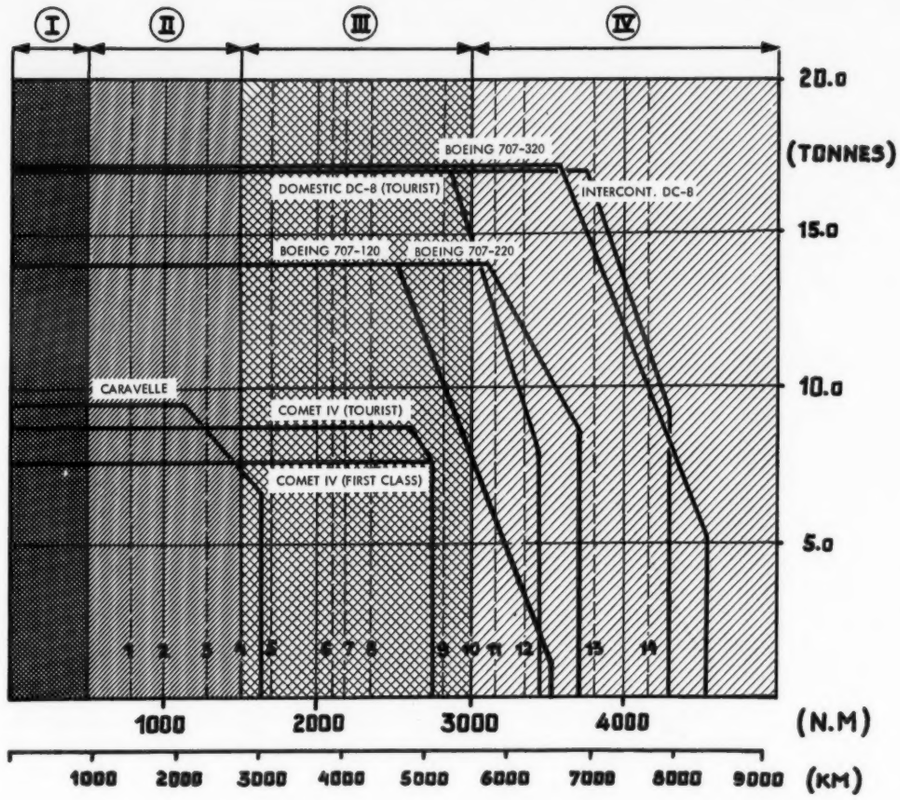


Diagram II: Payload-range characteristics (still air, with reserves) of the four jet transports shown in diagrams I and Ia, with classification of typical standard stages on world air services into range scales: I - short stages (0 to 500 nautical miles); II - medium stages (500 to 1,500 nautical miles); III - normal long stages (1,500 to 3,000 nautical miles); IV - extra long stages (more than 3,000 nautical miles). For details of payloads and ranges see Table V.

KEY TO STAGE LENGTHS

1. Paris–Tunis	790 nm	8. Cairo–Bombay	2,350 nm
2. Paris–Casablanca	1,020 nm	9. London–Montreal	2,820 nm
3. London–Tripoli	1,280 nm	10. London–New York	3,000 nm
4. Colombo–Singapore	1,480 nm	11. Paris–New York	3,160 nm
5. Sydney–Darwin	1,700 nm	12. Frankfurt–New York	3,340 nm
6. Montreal–Vancouver	2,100 nm	13. Honolulu–Auckland	3,800 nm
7. New York–Los Angeles	2,180 nm	14. Seattle–Tokyo	4,150 nm

... *Diagram Ia:* Four-jet Boeing 707-320 *Intercontinental Stratoliner* and four-jet Douglas DC-8 (both for extra long stages).

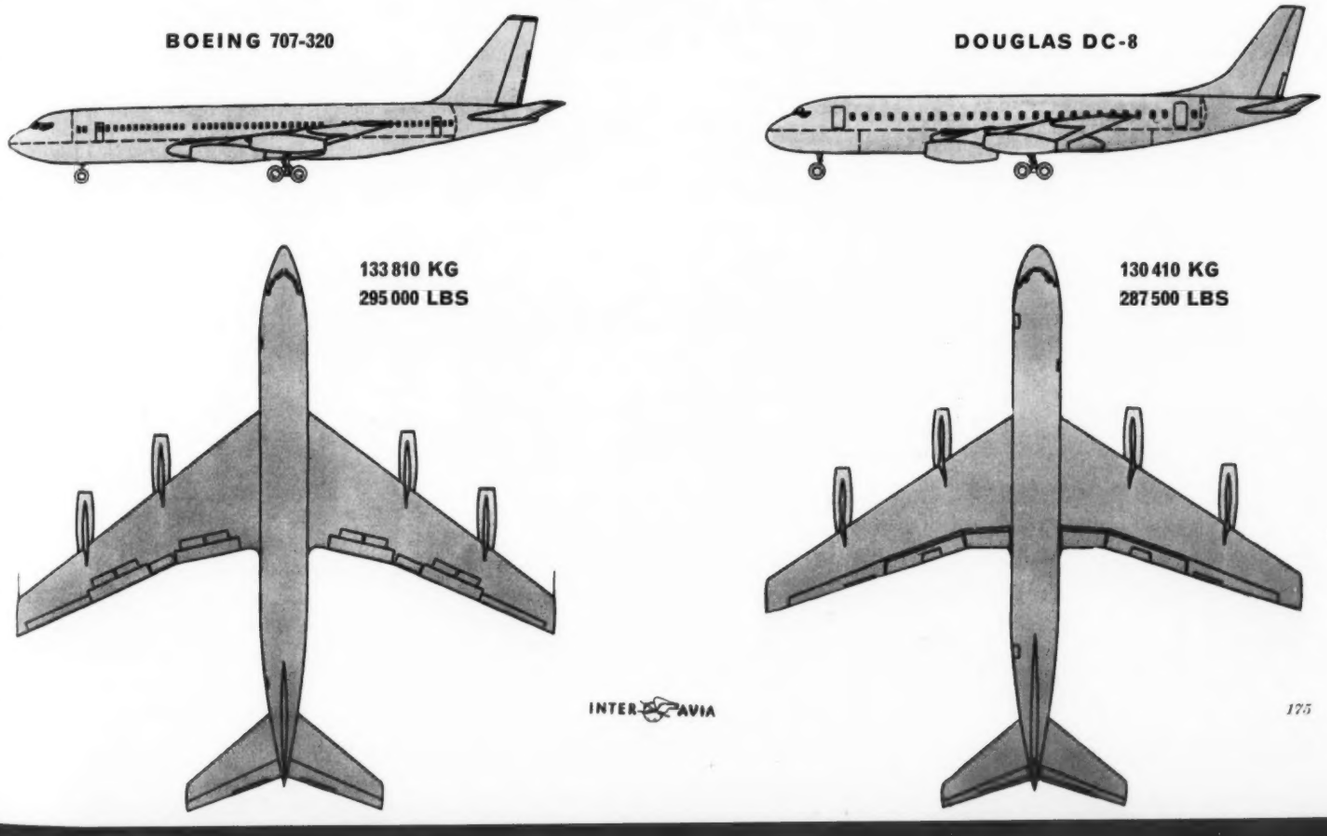


TABLE III: CHARACTERISTIC DATA FOR SELECTED HIGH-POWER JET ENGINES

Type	Description				Dimensions		Weight (lbs.)	Static thrust (without reheat) (lbs.)	Specific Consumption (lbs./lb.t./hr)
	Compressor	Compression Ratio	Combustion Chamber	Turbine	Length (ins.)	Diameter (ins.)			
Pratt & Whitney J-57 (JT3)	Two compressors 9 LP stages 7 HP stages	12.5 : 1	annular with 8 flame tubes	Twin turbine 2 LP stages 1 HP stage	130—140 ins.	40 ins.	4,100 lbs.	12,500 lbs.	0.78
Pratt & Whitney J-75 (JT4A)	Two compressors	+12 : 1	annular	Twin turbine	—	—	—	approx. 14,000—16,000 lbs.	approx. 0.75
Rolls-Royce *Conway*	Two compressors	+12 : 1	annular	Twin turbine	128.8	41.5	—	13,000 lbs.+	0.71
Rolls-Royce *Avon RA. 29*	Single compressor	—	annular with flame tubes	Single turbine	113 ins.	41.5 ins.	2,860 lbs.	10,500 lbs.	approx. 0.80
Rolls-Royce *Avon RA. 16*	Single compressor	—	annular with flame tubes	Single turbine	113 ins.	41.5 ins.	2,710 lbs.	9,000 lbs.	0.83

● *Stratoliner | DC-8 size class:* The two American manufacturers Boeing and Douglas based their jet transport designs on future needs in *world air transport*, on non-stop trans-Atlantic services, trans-Arctic and trans-Pacific routes. This meant ranges of over 3,000 nautical miles and hence a high fuel load. For technical reasons high gross weights and very powerful engines were therefore essential, and for economic reasons a high seating capacity had to be provided. As long as the super-powerful engines that would alone be adequate for this size class (with static thrusts of 12,000 to 18,000 lbs.) were not within sight, leading American manufacturers simply declined to make any premature experiments with commercial jet transports. They knew what they were after: world markets and with them large-scale business. — *Interavia* has published more than one statement on this subject.[2] For example, *Arthur E. Raymond*, Douglas Aircraft's Vice-President and Director of Engineering, said in 1952 that engines of the required thrust class would scarcely be available before 1957, and all building plans would have to be postponed until then. Meanwhile, as was expected, at any rate military versions of new high-power engines have been built and—in the case of the Pratt & Whitney J-57—been tested operationally during thousands of flying hours in American fighters and bombers. Also, the successor to the J-57, the P. &. W. J-75, has been running for some time on the bench (cf. *Table III*). At the request of the United States military authorities, no exact thrust or consumption figures (at all altitudes) have been released for these engines, though they are known in full detail to the industry. At any rate they formed the basis of the Boeing *Stratoliner* and Douglas DC-8 designs.

Points of similarity between Stratoliner and DC-8

As is illustrated by the comparative drawings in *diagrams I and Ia* and further underlined by the figures in *Table V*, the two American designs resemble each other to an amazing extent. Basic design, span, wing area, gross weight, fuel capacity are virtually similar. To be exact, only the wing sweeps show slight differences, and—obvious only to the expert—the design of ailerons and landing flaps. Only on closer inspection is it noticed that the Boeing 707 has almost twice as many, but smaller, windows as the DC-8, namely 49 on each side of the fuselage (instead of 25). — The resemblance even extends to the fact that both types have "transcontinental" and "intercontinental" versions with different engines, fuel loads and gross weights.

What was fit for world routes—the "large jet transport formula"—could only be good for the American transcontinental routes: medium-long block distances, for example 2,180 nautical miles between New York and Los Angeles, are matched in this case by an exceptionally high traffic volume. Leaving aside their time-saving appeal, typical of the "American way of life," the jet transports promise above all a further reduction in direct operating costs on these routes, thanks to their high seating capacity and annual mileage performance (cf. *diagram IV*). Competition in American domestic air transport is intense, as the "nonskeds" (the initiators of the tourist class) act as cats among the pigeons. Up to September 1955 the tourist fare from New York to Los Angeles (or San Francisco) was $ 99, but has since been cut to $ 80 and may fall still further.

One consideration that doubtless played a role in the transcontinental versions was that civil models of the smaller (and older) J-57 (JT3) turbojet will be obtainable earlier than the J-75 (JT4) super engine. While only the latter—or the equally powerful British Rolls-Royce *Conway* by-pass engine—can lift the extreme gross weights of the non-stop trans-Atlantic versions, the smaller JT3 in conjunction with lower take-off weights can get jet transports into operation at any rate on the American transcontinental routes. The Americans can thus gain ample experience of jet aircraft operations a few years before the big contest opens over the North Atlantic.

[1] "Where are America's Jet Transports?" in *Interavia* No. 6, 1952, p. 312, No. 8, 1952, p. 446, No. 9, 1952, p. 492.

Diagram IV: Comparison between direct operating costs (cents per seat-nautical mile) for all three versions of the Boeing 707 *Stratoliner* and those of modern long-range piston-engine aircraft. Figures based on A.T.A.'s revised 1955 method and depreciation period of 7 years for each aircraft. The still air range for the three versions (in nautical miles), with full utilization of seating capacity, is also shown.

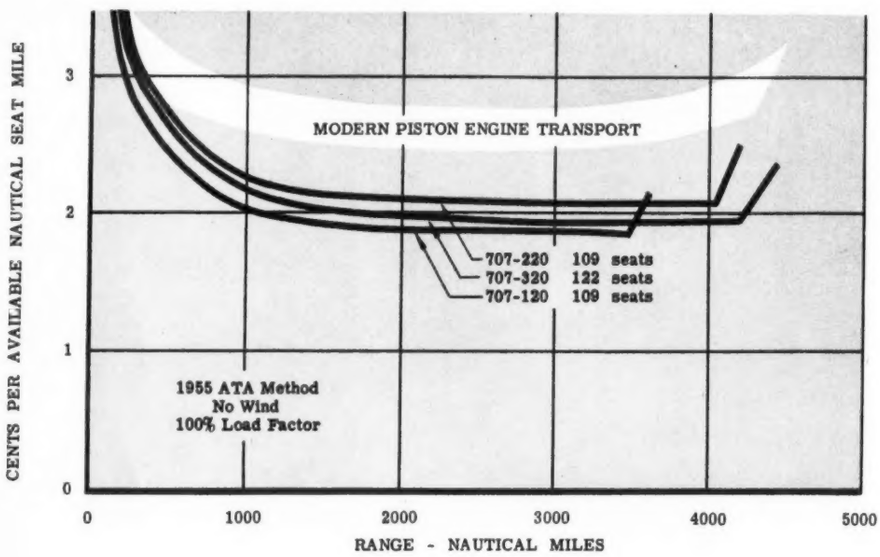


Table V: Characteristic data for jet transports under construction

Type	Boeing 707-120 Stratoliner	Boeing 707-220 Stratoliner	Boeing 707-320 Intercontinental Stratoliner	Douglas DC-8 Domestic I	Douglas DC-8 Domestic II	Douglas DC-8 Intercont. I	Douglas DC-8 Intercont. II	De Havilland Comet IV	SNCASE Caravelle
Power Plant (Number and Type)	4 × JT3C-4 (J-57)	4 × JT4A-3 (J-75)	4 × JT4A (J-75)	4 × JT3C-4 (J-57)	4 × JT4A-3 (J-75)	4 × JT4A (J-75)	4 × Conway	4 × Avon RA. 29	2 × Avon RA. 29
Alternative Power Plant	—	4 Conway	4 Conway	—	—	—	—	—	—
Max. Static Thrust at S. L.	4 × 12,500 lbs.	ca. 4 × 14,000 lbs.	ca. 4 × 16,000 lbs.	4 × 12,500 lbs.	ca. 4 × 14,000 lbs.	ca. 4 × 16,000 lbs.	4 × 13,000 lbs.	4 × 10,500 lbs.	4 × 10,500 lbs.
Span	130 ft. 10 in.	130 ft. 10 in.	141 ft. 6 in.	139 ft. 9 in.	139 ft. 9 in.	139 ft. 9 in.	139 ft. 9 in.	115 ft. 0 in.	112 ft. 6 in.
Overall Length	134 ft. 6 in.	134 ft. 6 in.	146 ft. 8 in.	148 ft. 10 in.	148 ft. 10 in.	148 ft. 10 in.	148 ft. 10 in.	111 ft. 6 in.	103 ft. 4 in.
Height	38 ft. 3 in.	38 ft. 3 in.	38 ft. 11 in.	42 ft. 4 in.	42 ft. 4 in.	42 ft. 4 in.	42 ft. 4 in.	28 ft. 6 in.	28 ft. 6 in.
Track	22 ft. 1 in.	22 ft. 1 in.	22 ft. 1 in.	20 ft. 10 in.	20 ft. 10 in.	20 ft. 10 in.	20 ft. 10 in.	28 ft. 2 in.	17 ft. 5 in.
Wing Area	2,433 sq. ft.	2,433 sq. ft.	2,908 sq. ft.	2758 sq. ft.	2758 sq. ft.	2,758 sq. ft.	2758 sq. ft.	2,121 sq. ft.	1,580 sq. ft.
Wing Sweep at 25% Chord	35°	35°	35°	30°	30°	30°	30°	22°	20°
Aspect Ratio	7.07	7.02	6.92	7.10	7.10	7.10	7.10	6.25	8.05
Design Gross Weight	225,000 lbs.[1]	250,000 lbs.[1]	295,000 lbs.[2]	265,000 lbs.[4]	265,000 lbs.[4]	287,500 lbs.[4]	287,500 lbs.[4]	152,500 lbs.	90,400 lbs.
Max. Usable T. O. Weight	225,000 lbs.[1]	250,000 lbs.[1]	280,000 lbs.[1]	250,000 lbs.[4]	265,000 lbs.[4]	287,500 lbs.[4]	287,500 lbs.[4]	152,500 lbs.	90,400 lbs.
Wing Loading at Design Gross Weight	92.5 lbs./sq. ft.	103 lbs./sq. ft.	101 lbs./sq. ft.[3]	96 lbs./sq. ft.	96 lbs./sq. ft.	104 lbs./sq. ft.	104 lbs./sq. ft.	72 lbs./sq. ft.	57 lbs./sq. ft.
Power Loading at Design Gross Weight	ca. 4.5 lbs./lb.	ca. 4.5 lbs./lb.	ca. 4.6 lbs./lb.	ca. 5.0 lbs./lb.	ca. 4.7 lbs./lb.	ca. 4.5 lbs./lb.	—	3.6 lbs./lb.	4.3 lbs./lb.
Max. Payload (Weight Limited)	31,000 lbs.[1]	31,000 lbs.[1]	38,000 lbs.[1]	41,470 lbs.	41,470 lbs.	38,690 lbs.	40,020 lbs.	21,100 lbs.	—
Max. Payload (Space Limited), Mixed Version	—	—	—	34,280 lbs.[4]	34,280 lbs.[4]	35,930 lbs.[4]	35,930 lbs.[4]	16,850 lbs.	—
Max. Payload (Space Limited), Tourist Version	—	—	—	37,910 lbs.[4]	37,910 lbs.[4]	37,910 lbs.[4]	37,910 lbs.[4]	19,250 lbs.	20,900 lbs.
Manufactorer's Weight Empty	—	—	126,000 lbs.[3]	114,489 lbs.[4]	118,265 lbs.[4]	120,737 lbs.[4]	115,877 lbs.[4]	ca. 68,000 lbs.	44,750 lbs.
Operating Weight Empty	111,200 lbs.	116,800 lbs.	132,700 lbs.[3]	119,726 lbs.[4]	123,532 lbs.[4]	128,862 lbs.[4]	123,726 lbs.[4]	ca. 68,900 lbs.	45,700 lbs.
Fuel Capacity	17,400 US. gals.[1]	18,078 US. gals.[1]	23,580 US. gals.[1]	17,600 US. gals.[4]	17,600 US. gals.[4]	21,615 US. gals.[4]	21,615 US. gals.[4]	8,750 Imp. gals.	3,960 Imp. gals.
Fuel Capacity	113,000 lbs.	117,500 lbs.	153,000 lbs.[1]	114,400 lbs.[4]	114,400 lbs.[4]	140,500 lbs.[4]	140,500 lbs.[4]	ca. 68,200 lbs.	30,800 lbs.
Fuel Capacity excl. Taxiing & T. O.	111,350 lbs.	115,400 lbs.	150,900 lbs.	112,750 lbs.	112,300 lbs.	138,400 lbs.	138,850 lbs.	ca. 66,770 lbs.	30,090 lbs.
Perm. Payload with Max. Tankage	2,450 lbs.	17,700 lbs.	11,400 lbs.[3]	17,520 lbs.	29,170 lbs.	20,240 lbs.	24,920 lbs.	ca. 16,830 lbs.	14,600 lbs.
Perm. Fuel Tankage with Max. Payload, Tourist Version	82,800 + 1,650 lbs.	102,000 + 2,100 lbs.	124,300 + 2,100 lbs.	92,000 + 1,650 lbs.	103,200 + 2,100 lbs.	120,400 + 2,100 lbs.	125,800 + 1,650 lbs.	—	—
Max. Landing Weight	165,000 lbs.[1]	175,000 lbs.[1]	190,000 lbs.[1]	189,000 lbs.[4]	189,000 lbs.[4]	190,500 lbs.[4]	190,500 lbs.[4]	113,000 lbs.	79,200 lbs.
Design Zero Fuel Weight	142,000 lbs.	147,200 lbs.	170,000 lbs.[3]	161,200 lbs.[4]	165,000 lbs.[4]	167,550 lbs.[4]	163,750 lbs.[4]	90,000 lbs.	—
Passenger Capacity									
Tourist Version	125[1]	125[1]	147[1]	144[4]	144[4]	144[4]	144[4]	76	91
First Class Version	109[1]	109[1]	122[1]	—	—	—	—	58	70
Mixed Version	49 + 69[1]	49 + 69[1]	34 + 90[1]	122[4]	122[4]	132[4]	132[4]	—	—
Cargo Capacity, Total	1,290 cu. ft.	1,290 cu. ft.	1,500 cu. ft.	1,445 cu. ft.[4]	1,445 cu. ft.[4]	1,445 cu. ft.[4]	1,445 cu. ft.[4]	545 cu. ft.	—
Forward Compartment	490 cu. ft.	490 cu. ft.	700 cu. ft.	—	—	—	—	—	—
Rear Compartment	800 cu. ft.	800 cu. ft.	800 cu. ft.	—	—	—	—	—	—
Performance									
Max. Level Flight Speed	515 kn.[1]	525 kn.[1]	520 kn.[1]	—	—	—	—	—	—
Garanteed Max. Speed at 30,000 ft., at 220,000 lbs and Max. Cruising Thrust	—	—	509 kn.[3]	486 kn.[4]	509 kn.[4]	509 kn.[4]	505 kn.[4]	—	—
Max. Cruising Speed over Long Stages	—	—	457 kn.	—	—	—	—	—	—
Max. Cruising Speed over Normal Stages	—	—	480 kn.	—	485 kn.	485 kn.	480 kn	435 kn.	415 kn.
Max. Mach Number during Descent	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.81	0.81
Max. Mach Number in Level Flight	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.76	—
Max. Approach Speed with Full Flaps	—	—	185 kn.	—	—	—	—	—	—
Max. Speed with Landing Gear Lowered	—	—	270 kn.	—	—	—	—	—	—
CAR-Runway Length for T. O. at Max. T. O. Weight, S. L. (ICAN)	8,200 ft.[1]	8,800 ft.[1]	9,800 ft.[1]	9,440 ft.[4]	8,640 ft.[4]	8,760 ft.[4]	9,000 ft.[4]	7,140 ft.	6,100 ft.[3]
CAR-Runway Length for Landing at Max. Landing Weight, S. L. (ICAN)	—	—	ca. 6,400 ft.	6,680 ft.[4]	6,630 ft.[4]	6,690 ft.[4]	6,690 ft.[4]	—	3,800 ft.[3]
Fuel Consumption									
Starting	ca. 330 lbs.	ca. 420 lbs.	ca. 420 lbs.	ca. 330 lbs.	ca. 420 lbs.	ca. 420 lbs.	ca. 330 lbs.	ca. 330 lbs.	ca. 160 lbs.
5 min. Taxiing	ca. 660 lbs.	ca. 840 lbs.	ca. 840 lbs.	ca. 660 lbs.	ca. 840 lbs.	ca. 840 lbs.	ca. 660 lbs.	ca. 550 lbs.	ca. 275 lbs.
Take-Off	ca. 660 lbs.	ca. 840 lbs.	ca. 840 lbs.	ca. 660 lbs.	ca. 840 lbs.	ca. 840 lbs.	ca. 660 lbs.	ca. 550 lbs.	ca. 275 lbs.
Climb to 33,000 ft. at T. O. Weight (Time and Distance of Climb)	—	—	ca. 10,350 lbs. (20 min., 140 n. m.)	—	—	ca. 10,350 lbs. (20 min., 140 n. m.)	—	—	—
Normal Cruising Flight	—	—	ca. 12,800 lbs./h	—	—	ca. 12,800 lbs./h	—	—	—
Descent from 40,000 ft. (Time and Distance of Descent)	—	—	ca. 2,200 lbs.	—	—	ca. 2,200 lbs.	—	ca. 2,200 lbs.	—
Fuel Reserves									
For 260 n. m. Detour and 60 min. Holding at 15,000 ft.	ca. 16,500 lbs.	ca. 16,700 lbs.	ca. 16,700 lbs.	16,500 lbs.[4]	16,680 lbs.[4]	17,180 lbs.[4]	16,800 lbs.[4]	ca. 14,300 lbs.	—
For Deicing	—	ca. 1,000 lbs.	ca. 1,000 lbs.	—	—	—	—	ca. 1,000 lbs.	—
Still Air Ranges (with Reserves)									
Normal Range, Tourist Version (at Max. Payload of)	ca. 2,500 n. m. (31,000 lbs.)	ca. 3,200 n. m. (31,000 lbs.)	ca. 3,650 n. m. (38,000 lbs.)	2,860 n. m.[4] (37,910 lbs.)	3,290 n. m.[4] (37,910 lbs.)	3,760 n. m.[4] (37,910 lbs.)	4,050 n. m.[4] (37,910 lbs.)	ca. 2,600 n. m. (19,250 lbs.)	1,140 n. m. (20,900 lbs.)
Max. Range (at Reduced Payload of)	ca. 3,500 n. m. (2,450 lbs.)	ca. 3,700 n. m. (17,700 lbs.)	ca. 4,650 n. m.[5] (11,400 lbs.)	ca. 3,580 n. m. (17,520 lbs.)	— —	ca. 4,400 n. m. (20,240 lbs.)	— —	ca. 2,750 n. m. (16,850 lbs.)	1,640 n. m. (14,600 lbs.)
Normal Range, Tourist Version at Reduced T. O. Weight for Existing Runways of 6,500 ft. Length (S. L.)	—	—	—	1,540 n. m.[4]	2,170 n. m.[4]	2,570 n. m.[4]	2,770 n. m.[4]	—	—

[1]) According to Boeing Catalogue D-17,776, dated February 1956
[2]) According to Sabena Figures
[3]) According to Air France Figures
[4]) According to Douglas Information of February 9th, 1956
[5]) Obtainable only with increased T. O. Weight (295,000 lbs); CAR-Runway Length correspondingly greater

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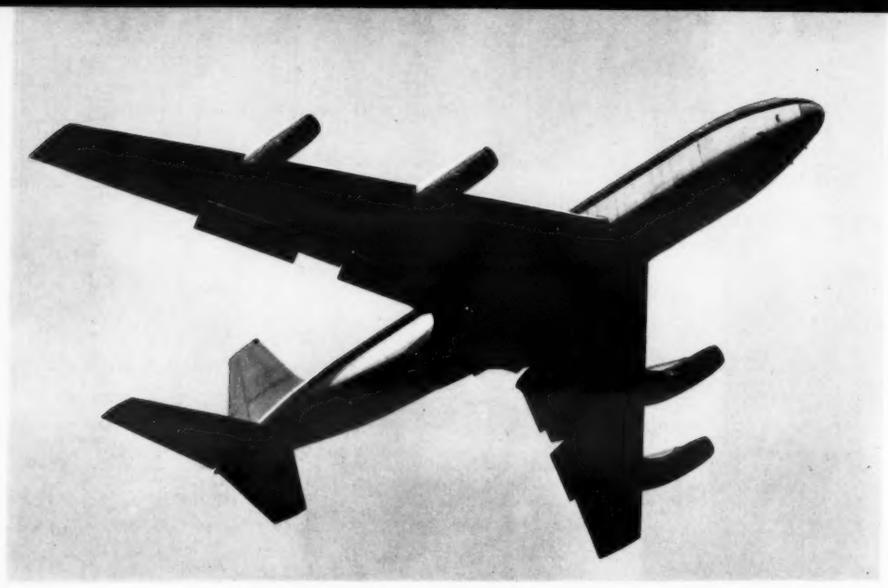


Prototype of the Boeing 707, shortly after take-off: the nose wheel unit is already retracted and has disappeared into the fuselage; the main undercarriage is inside its bay (centre of fuselage) and is just being covered by the hydraulically operated doors; all four double-slotted flaps are in take-off aid position; outboard and inboard ailerons are in operation.

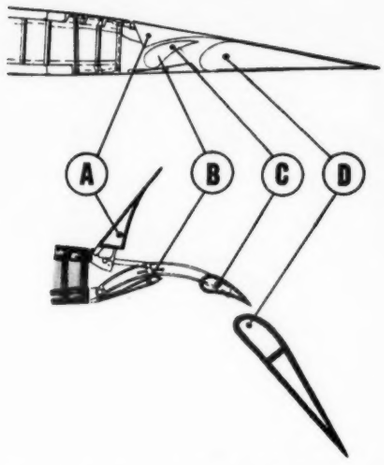


Diagram of spoilers and double-slotted flaps in the Boeing 707: A - spoiler; B - door; C - fore flap; D - rear flap.

Details of the Boeing 707

The transcontinental and intercontinental versions of the Boeing 707 differ in power plant and dimensions. The intercontinental versions are 10 ft. 8 ins. wider in span and 12 ft. 2 ins. longer. There are corresponding differences in wing areas, fuel capacity, seating capacity and cargo volume, all of which naturally affect weights and performance (cf. *Table V*).

The fastest of the three versions will be the *707-220* with Pratt & Whitney JT4A engines. With a max. gross weight of 250,000 lbs.—i. e., with a wing loading of 103 lbs./sq. ft. it will be able to manage with "medium" runways of about 8,850 ft., but will not have the extra long range of the intercontinental 707-320. In addition, because of its lower seating capacity and high fuel consumption it is somewhat more costly in operation than the other versions (cf. *diagram IV*).

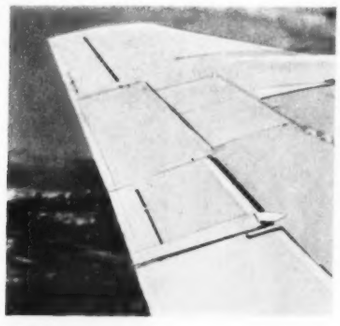
On the other hand the most economical version and the one with the longest range by virtue of its fuel capacity, the *707-320,* is handicapped at the moment by the fact that the maximum thrust to be expected from the fully developed JT4 engine is secret. Maximum thrust—and runway length—determine the usable take-off weight. If the 707-320 were operated only at its present take-off weight of 280,000 lbs.—for which the makers demand a sea level runway length of 9,680 ft.—the full fuel capacity of 23,580 U.S. gals. could not be used without reducing payload to zero. However, if an overload take-off weight of 295,000 lbs. were used, as recently announced by Sabena Belgian Air Lines, it would be possible to carry a payload of roughly 5 tons with full tanks . . . but the runway length would have to be at least 11,400 ft.

Wing unit: The 707's twin-spar wing has a slightly cambered airfoil with a thickness/chord ratio of about 9%, with noticeably drooped leading edge. Angle of sweep is 35 degrees at 25% chord; max. permissible Mach number in descent is 0.94. The wing trailing edge carries two pairs of ailerons and two pairs of spoilers. These are arranged from outboard to inboard as follows: aileron; flaps plus spoiler; aileron; flaps plus spoiler; slotted flaps (see *pictures*). The total fuel stock is carried in integral tanks in the wing unit.

Fuselage: Of *oval* section with a maximum external width of 12 ft. 4 ins. and overall height of 14 ft. 2 ins. Divided by the cabin floor into upper main compartments (for passengers and crew) and several lower compartments (for nose-wheel unit, baggage, main undercarriage units, baggage or cargo), the 707's fuselage recalls the Boeing *Stratocruiser's* famous "double-bubble" configuration. In the standard version passengers sit in rows of five abreast (2 + 3), in the tourist version of six abreast. A total of 98 small windows spaced at intervals of 20 ins. provide good outside view—not that there is much to be seen in the stratosphere. The manufacturers have evidently worked on the assumption that even the safest window could possibly fail during the long operating life of a jet aircraft and have tried to keep the inevitable drop in pressure in such a case to the minimum, so that the pilot has more time for a life-saving rapid descent to denser atmosphere. The large number of windows also permits greater flexibility in seating arrangements. The maximum pressure differential between ambient pressure at cruising altitude and lowest cabin pressure is 8.6 lbs./sq. in. Provision is made for two large passenger doors to port, two small doors for supplies to starboard and four emergency

Operation of spoilers and double-slotted flaps: **1** during take-off the two flaps on each wing half are partially down and both inboard and outboard ailerons are moved in common. **2** During cruise all four flaps are up and the outboard ailerons are locked. **3** During let-down flaps (and fore flaps) are further down than for take-off, and (controllable) spoilers extended to help control rate of descent. **4** During landing approach double-slotted flaps are fully extended, while spoilers are scarcely used; inboard and outboard ailerons are again used jointly for lateral control (as in 3).

1



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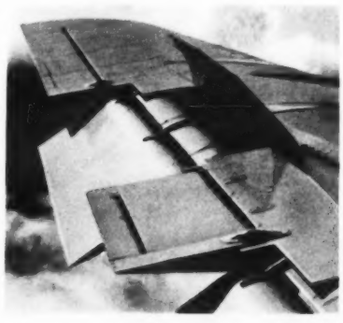

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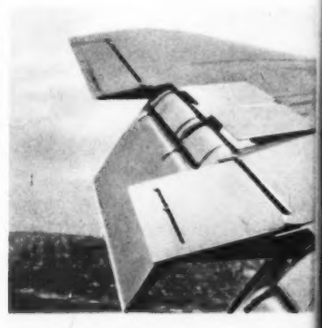

4

AVIATION

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FIAT

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Dotted line shows how airplane passed between storm cells in its flight path.

Minutes and miles are saved when a pilot is able to find a smooth path through turbulent areas.

AVQ-10 antenna mounted in nose of airplane scans the forward areas, enabling the pilot to evaluate storm conditions far ahead.

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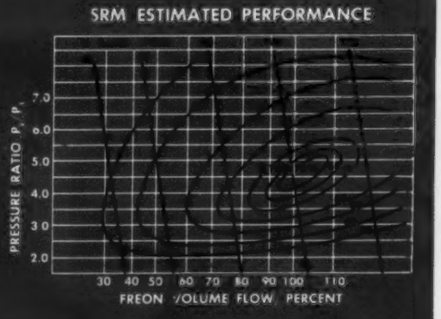
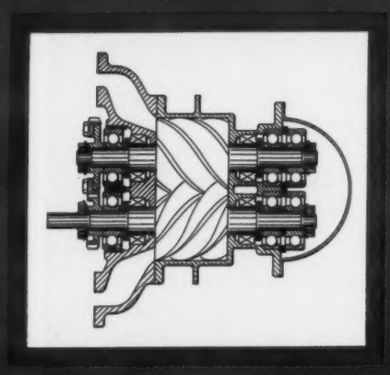
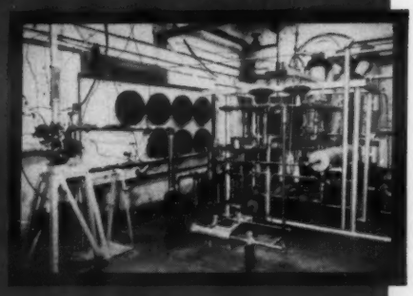
FOR FREON REFRIGERATION



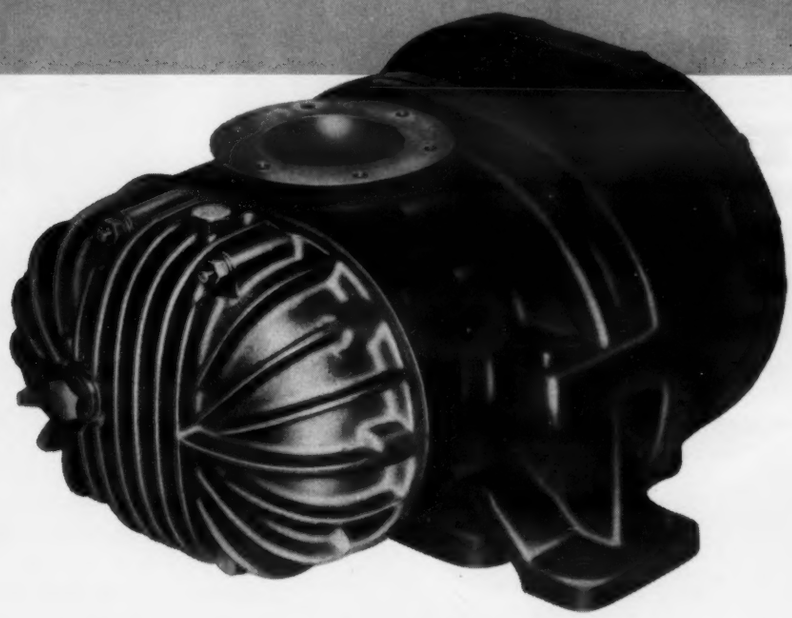
Performance Map Shows Compressor's Efficiency



Cutaway View Showing Compression Principle



Installation in Stratos Freon Refrigeration Test Cell



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Stratos' positive displacement compressor is ideally suited for pumping gases against high pressure ratio heads at relatively low flow – volumes such as are involved in freon refrigeration systems for transport aircraft. Compression ratio is built in, avoiding backflow compression, and is independent of speed. The compressor is surge free and simple in construction, requiring no complex valving or control systems. It can operate at high speed – up to 40,000 rpm – keeping unit and drive, size and weight down. Drive can be hermetically sealed electric, turbine, hydraulic or direct from an engine.

Two helical lobe rotors trap the entering gas, compress it in a confined area and deliver it to an exit port at the design pressure. The rotors are of a patented design, with a unique form already proved in a variety of industrial and aircraft applications.

Stratos currently is developing freon refrigeration systems, incorporating this compressor, for use in large transport aircraft. Other applications – such as pressurizing of high altitude aircraft – are being developed.

For further information on this interesting development in compressors write to:

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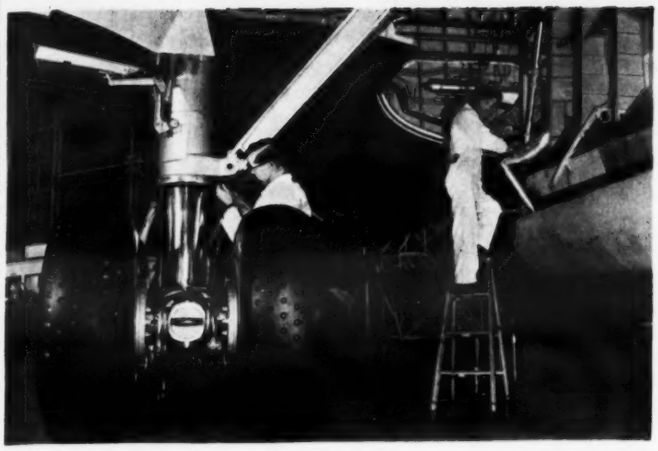


Port main undercarriage unit in the Boeing 707 (four wheels) and bay with folding doors; all hydraulic elements are easy of access.

The Boeing 707-120 *Stratoliner's* power units: Pratt & Whitney J-57 (civil designation JT3C-4) two-spool turbojets mounted in easily accessible pods.

exits, all with multiple bolt fastenings to safeguard against hinge or lock failure.

Tail unit and controls: The control surfaces on the wing have already been enumerated. They are supplemented by the sharply swept tail plane unit 51 ft. 8 ins. in span (39 ft. 8 ins. in the smaller versions) and the rudder unit rising to a height of 38 ft. 11 ins. (38 ft. 3 ins.) above the runway. Despite their vast dimensions, all control surfaces are operated manually, by means of spring-loaded Flettner servo tabs at the ends, thus requiring no hydraulic power boosters. This is one of the "returns" on Boeing's long and costly experimental work on the B-47 and B-52 bombers. Only the horizontal tailplane is electrically operated, but has an emergency manual control system. The double-slotted flaps and spoilers are operated hydraulically, with again a manual system for emergencies, at any rate for the flaps. The spoilers, which work independently of the flaps and are individually controllable, help the pilot to regulate his rate of descent and improve lateral control at low speeds. The 707's rolling speed (about the longitudinal axis) is astonishing. It is up to 35°/sec with landing flaps down and roughly 22°/sec with flaps closed and at a speed of 250 knots. At high speeds, i. e., as soon as the flaps are fully closed, the outboard ailerons are locked in neutral position, so that aero-elasticity will not cause the control surfaces to reverse. In his report for *Aviation Week*[3] Chief Test Pilot A. M. "Tex" Johnston declared himself well satisfied with the flight characteristics of the 707 prototype. The aircraft could be flown with one hand without fatigue even at high speeds, showed good-tempered behaviour at low speeds, and could descend at nearly 13,000 ft. per minute.

Undercarriage: Twin-wheel nose unit retracting forwards and two main units with four-wheel bogies each, folding sideways into fuselage bays. All three undercarriage bays are completely closed during take-off and landing as well as in flight.

Power plant: The four Pratt & Whitney JT3C-4 or JT4A, or Rolls-Royce *Conway* engines are suspended in pods and hence are particularly easy of access. Devices for thrust reversal and noise reduction are under development.

Equipment: The electrical system for 115/200 Volt 400 c/s current has three generators and three converters for 28-Volt d. c., and a 24-Volt battery of 36 Ah capacity. Two independent hydraulic circuits for 3,000 lbs./sq. in. with four hydraulic pumps and two storage containers are used to operate the undercarriage, double-slotted flaps and spoilers. Four compressors provide compressed air; the outer wings are de-iced by hot air from the engines; electrical de-icing for the inner wings and tailplane; comprehensive radio communications and navigation equipment.

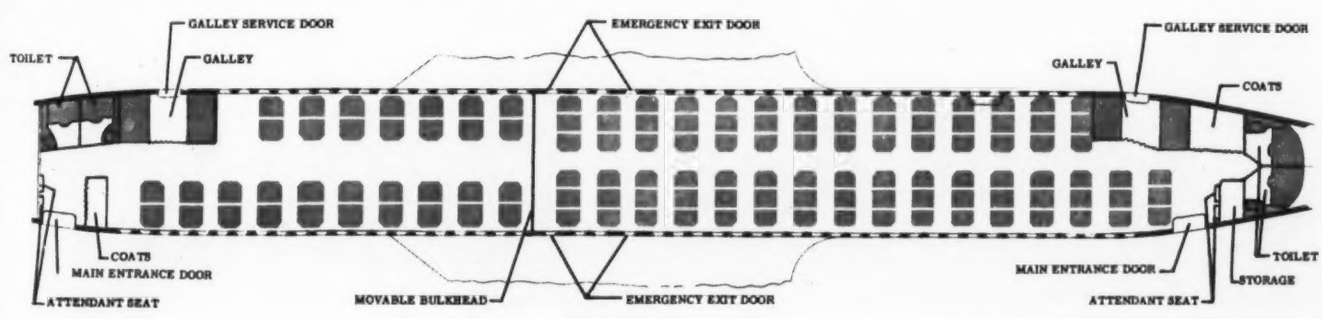
[3] "Flight Characteristics of the 707 Airliner", *Aviation Week*, November 21st, 1955, pp. 21-25

Details of the Douglas DC-8

No fewer than *four versions* of the DC-8 are offered, two each for transcontinental and intercontinental operations (cf. *Table V* and accompanying *box*). All versions are identical in external configuration, but differ in power plant, structure, weights, capacities and ranges.

Table V reveals in particular that the *P. & W. JT4A* jet is to be used at two different power ratings, a so-called normal rating for the more powerful domestic version (with full "usable" gross weight of 120 tons); and an advanced rating for the intercontinental version. No exact figures are obtainable, however, for either sea level static thrust or thrust at cruising altitude. The values indicated—and the consumption figures—are merely "educated guesses" by *Interavia's* Study Group.

Seating plan for a 124-seat mixed version of the Boeing 707, for 34 first-class and 90 tourist passengers



THE NEW DC-8

BY ARTHUR E. RAYMOND,
VICE PRESIDENT-ENGINEERING, DOUGLAS AIRCRAFT CO., INC.

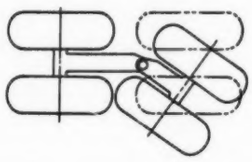
The latest DC-8 specifications* are the result of a process of refinement which has been taking place over the past six months or so, of active negotiation with customer airlines. Of course, the basic design itself has its roots in the long succession of civil transports we have built over the past twenty-five years and the various military jets, large and small, we have turned out over the past ten. We have been in consultation with airlines here and abroad regarding their jet requirements for at least three years but it is only in the period since last June, when we announced definite plans for going ahead, that the DC-8 has come into final focus.

We are now offering an airplane which, in the process of evolutionary development, is somewhat larger than it was six months ago, with a wing span of 139 ft. 9 in., length of 148 ft. 10 in. and clearance height of 42 ft. 4 in.

The length of the 30-degree swept wing has been increased at the root, adding five feet of span. This provides 160 sq. ft. of additional wing area and permits 20,000 lbs. more fuel to be carried.

The fuselage has been lengthened 100 inches to provide space for up to 19 more passengers in tourist arrangements.

Main undercarriage unit of the DC-8



There are two weight levels: 265,000 lbs. gross we ght for domestic or general use and 287,500 lbs. for the intercontinental or long-range operator.

Because of the over-all weight increase, the landing gear has been changed from a coaxial quad to a unique type of dual tandem gear. The rear pair of each set of four wheels swivels to preserve the ability to maneuver the airplane sharply in congested ramp areas without tire scrubbing.

The long range DC-8 differs from the domestic version only in its added fuel capacity and the greater structural strength needed to carry the additional fuel. The differences in configuration are limited to thicker skin and stringer material within the wing structure, aft portion of the fuselage, and horizontal stabilizer. The landing gear also is heavier on the airplane with the larger gross weight.

Because all DC-8s have the same dimensions, the aerodynamic characteristics and location of major elements are identical. Of particular importance is uniformity in the air conditioning, electrical, hydraulic and control systems.

This basic airplane is available in domestic models with either the Pratt & Whitney JT3 (J-57) or JT4 (J-75) turbojet engines and in extended range models with the larger engine. It is also being offered with the Rolls-Royce **Conway** turbofan engine.

In addition to the obvious performance and economic advantages which the DC-8 offers the operator and the travelling public, it contains many technological improvements and refinements that contribute to service reliability and ease of maintenance, the result of our long and broad association with airline operations.

* See Table V

Model of the Douglas DC-8.

On the other hand, direct operating costs for all four versions were calculated *exactly* by the manufacturers according to the new A.T.A. method (1955) and communicated to *Interavia* early in February 1956.

TABLE VI: A.T.A. OPERATING COSTS FOR THE DC-8

Type	DC-8 Domestic I	DC-8 Domestic II	DC-8 Intercontinental I	DC-8 Intercontinental II
Power plant	JT3C-4	JT4A-3 Normal rating	JT4A Advanced rating	Conway
Mixed version, seats	122	122	132	132
Baggage or cargo	14,150 lbs.	14,150 lbs.	14,150 lbs.	14,150 lbs.
Still air range (with reserves)	3,080 nm	3,500 nm	3,880 nm	4,180 nm
Direct costs per aircraft-nautical mile	$1.77	$1.98	$2.22	$2.12
Direct costs per seat-nautical mile	1.45 cents	1.62 cents	1.68 cents	1.60 cents
Tourist version, seats	144	144	144	144
Baggage or cargo	14,150 lbs.	14,150 lbs.	14,150 lbs.	14,150 lbs.
Still air range (with reserves)	2,860 nm	3,290 nm	3,760 nm	4,050 nm
Direct cost per seat-nautical mile	1.23 cents	1.37 cents	1.54 cents	1.46 cents

Little has been released about the structure of the new DC-8's wing and fuselage. Details of the new-type landing gear are given by A. E. Raymond himself (see box). Ailerons and rudder are controlled via servos, and elevators manually. A hydraulic system is provided for adjustments to the tailplane; four turbo air compressors supply pressurizing air (for a maximum pressure differential of 8.77 lbs./sq. in.); de-icing is by air bled from the engines.

Electrical system: 115/200 Volt 400 c/s three-phase A. C. from four generators; four converters for 28 Volt 25 Amp D.C.; 24 Volt 11 Ah accumulators. — *Hydraulic system:* pressure 3,000 ft./sq. in.; two pumps; one storage tank. All versions of the DC-8 will of course be fitted with the latest radio communications and navigation equipment.

*

Technical details of the *S.N.C.A.S.E. Caravelle* and *de Havilland Comet IV* have already been published in *Interavia*.[4]

The above is the first attempt at a comparison between the nine commercial jet aircraft types in construction by four different manufacturers. Even if some of the data given here should change in the course of development and testing of the new aircraft, the general picture—as regards the types now being built—should remain sufficiently complete and accurate. However, it may well be that new rivals will appear to challenge the present manufacturers of jet transports. — *Preparation of the above article seemed indicated in order to provide an examination of the technical aspects of the coming new phase of air transport.*

[4] *Interavia* No. 10, 1955, pp. 769-773

The Air Hostess Told Us...

". . . and we must fill them with more passengers than we've ever . . .", we said. Stop it, moans Esmeralda, our Favourite Air Hostess, from the editorial chair she has appropriated as usual, please do stop. I don't want to hear *that* one any more—Aviation Week started it, now everybody quotes it, you've plastered it in the Leading Article of this issue, the S.B.A.C. repeated it in their weekly newsletter, Mr. Robert Aldrich spouted it at the Jet Age Conference in Washington on February 3rd.

The way you're going on, she continues, one might think that no one ever made any effort at all to stick more passengers into more aeroplanes than ever before. And all the time the airlines are just doing that—trapping passengers. I know, she says, because I help. I smile at them, I stuff chewing gum into their ugly mouths, I wrap them up in blankets. I address even the most miserable rake as Sir. One airline gives them orchids and Arpège, another leis, a third fills them up with Californian cider (pardon me, champagne). And now there is the night club . . .

Night club? we ask. Yes, the celestial night club, the flying girlie show, the speakeasy of the air. Your mind is wandering, we say gently, night clubs are on the ground, preferably underground, we're familiar with most of them. That just shows you know nothing about flying, Esmeralda smiles, have a look at this picture. A full-fledged cabaret in the air. Rhythm aboard the Super-Gee—Super-Jive I'd call it. An orchestra with safety belts—not too tight for the hip-wiggling red-hot momma. Cha-cha, mambo and the conga in the tropopause. All in order to get tired old businessmen on to the "Tropicana Special" which Compañia Cubana de Aviación will inaugurate between New York and Havana this spring. And then you say the airlines are not yet trying.

And that is not all, says Esmeralda. B.O.A.C., for instance, want more passengers on their Far East routes. What do they do? Hire Oriental stewardesses, of course. Eight Chinese, and five Japanese, including Shirley Dee from Hong Kong and Nachiko Sagawa from Tokyo. All perfectly true—my friend Diana had to take one out to Hong Kong the other day. And it's having repercussions.

Cubana's Super-Jive.

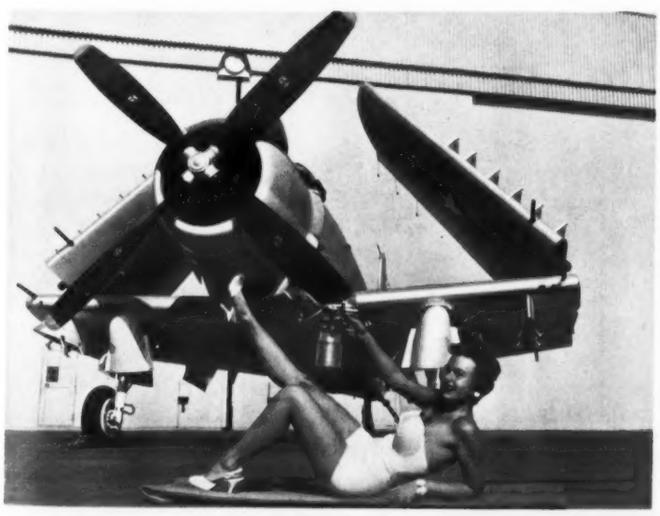
Kimonos and Ham Sandwiches – J.A.L.'s Stewardesses.

Japanese Air Lines has Japanese air hostesses, as you know. Well, they simply *have* to be Japaneser than the Europeans, so—bingo—they order their girls into kimonos and funny shoes. With the result that the Japanese, who are painfully learning the benefits of the American Way of Life, let out one howl of dismay at this retrograde step. The girls say kimonos are only for parties—and how can you serve a dry martini, coffee or a ham sandwich in those long skirts with flapping sleeves? Apart from that they think their uniforms convey "a much better impression . . ."

Worse things will come, sighs Esmeralda. The airlines will become exhibitions of national cheesecake, like the American aircraft manufacturing business (see below). British European Airways will have Lady Godiva riding down the aisle. Garuda will have Balinese dancing girls serving Scotch. Swissair will yodel and play music boxes and K.L.M. will play basketball with an Edam cheese and hand out tulips. The Spaniards will have Flamenco dancers and their companions will murder every passenger who looks twice. What East African Airways will present in the form of local Mau-Maus defies the wildest imagination. And since the Russians will soon fly to all points in Europe and everybody else to Russia, Aeroflot will have Cossacks on manoeuvres in the cabin and ballet stars distributing Geneva spirit (Bols).

A sad end is in sight, Esmeralda prophesies. Huge jets are coming —bigger and better aircraft. Bigger and better attractions. How do you expect the crew to stay in their places . . . one by one they will drift into the cabin to watch the fun. After that everybody will travel by boat.

American Industrial Cheesecake. Anne Gordon publicizes – the new colour scheme of U.S. naval aircraft. The thing in the background is a Douglas AD *Skyraider*.



Jet Transport

Some of the Problems in the Certification of Jet Transport Aeroplanes

by H. C. Black, B. Sc., Assistant Chief Technical Officer, Air Registration Board, London

With the increasing complexity of modern civil aircraft, it is seldom possible to base an airworthiness investigation solely on a set of printed requirements. Thus a proper examination for potential dangers—an essential part of certification—involves a process of probing, which is best summed up in the Air Registration Board's stock question "What happens if . . .?" In no field of airworthiness today is it necessary to ask this question more frequently than in the certification of jet transport aeroplanes.

Many of the problems in the certification of jet transport aeroplanes are not directly associated with the nature of the power plant itself and would appear in a similar form in any aeroplane which flew at comparable speeds and heights. However, the continual search for higher and higher speeds without excessive sacrifice in economy has driven operation to ever higher altitudes, and the characteristics of the jet engine, which must be operated at great heights to keep fuel consumption within reasonable bounds, accentuate this trend.

The first problems to be overcome, therefore, are the comparatively straightforward engineering problems of making the vehicle work at high altitudes and in the associated low temperatures. This has necessitated the housing of a large amount of equipment in the fuselage itself where it can be kept under reasonable conditions, while the equipment which remains exposed must be suitably designed for the conditions; as a simple example, special precautions are necessary to prevent excessive brush wear in electrical equipment.

Pressure Cabins

Perhaps our most pressing problem, and certainly the one which has received the most publicity recently, is the design of the pressure cabin. The high differential pressure in a modern pressure cabin, together with the enormous amount of stored energy contained within it, clearly mean that the integrity of the cabin must be assured beyond doubt. It appears to be essential to ensure not only that the cabin has a very pessimistically assessed safe "fatigue life" (and preferably an "infinite life"), but also that, even if a failure does occur, it will not spread catastrophically. Luckily, both these requirements can be met by designing to a suitably low stress level throughout, but attention to the whole of the detail design is also important; firstly, to ensure that no local high stresses occur and, secondly, to investigate the consequences should a failure occur in some re-inforcement member such as a window surround.

We have always found that it is essential to carry out numerous large scale fatigue tests on component parts of pressure cabins, but, from our experience in recent years, it has become apparent that these must be backed up by a full scale fatigue test of a complete fuselage. The expense of such a test is of course enormous, and we all hope it will not become a permanent feature of the certification of pressure cabin aeroplanes. However, with the present state of knowledge we can see no easy alternative.

Flying Qualities

In determining the flying qualities of a modern high speed aeroplane, one at once becomes involved not only in the problems associated with flight at high equivalent airspeeds, but also in those associated with flight at high Mach numbers. The possibility of control overbalance due to ice accretion and the need for some tolerance in manufacture set a limit to the degree of aerodynamic balance which is possible with what has been regarded in the past as a conventional control, and thus the designer of any large jet transport (particularly those with a large centre of gravity range) is driven to give the pilot some servo assistance. Unfortunately, whether this takes the form of power operation, power boost, pure servo tabs or even spring tabs, some of the features of the controls which the pilot is used to are liable to be lost. A full discussion of what has come to be known as control "feel" would be out of place in this article, but apart from the necessity to provide controls which make the aeroplane easy and pleasant to fly and which preclude the possibility of flutter, it is essential to protect the aeroplane against being overstressed by inadvertent control application, particularly in extreme turbulence.

Our present view, supported by some accident evidence, is that it is important to provide a minimum elevator control force of 60 lbs. to reach proof normal acceleration at the most extreme conditions of weight and centre of gravity.

Operating Speeds

An aeroplane flies between two limiting speeds. The lower speed is the stall and the higher speed is the maximum demonstrated flight speed. The latter may of course be limited purely by structural considerations, but a jet transport may also be limited by control troubles such as pitching or rolling tendencies, or by buffet. For a high flying aeroplane both these speeds vary with Mach number and approach each other with increasing altitude until they coincide (Figure 1) and the aeroplane has a zero speed range at its "aerodynamic ceiling".

During the certification process other speed limitations are established. Common prudence dictates a margin above the stall and the stall buffet, while the possibility of inadvertent speed increases leads to the establishment of a "Never-exceed-speed" (V_{ne}) and a "Normal-operating-

Figure 1. Note: In drawing this diagram it has been assumed that the tropopause does not exist. Operating experience has shown that the height of the tropopause is extremely variable.

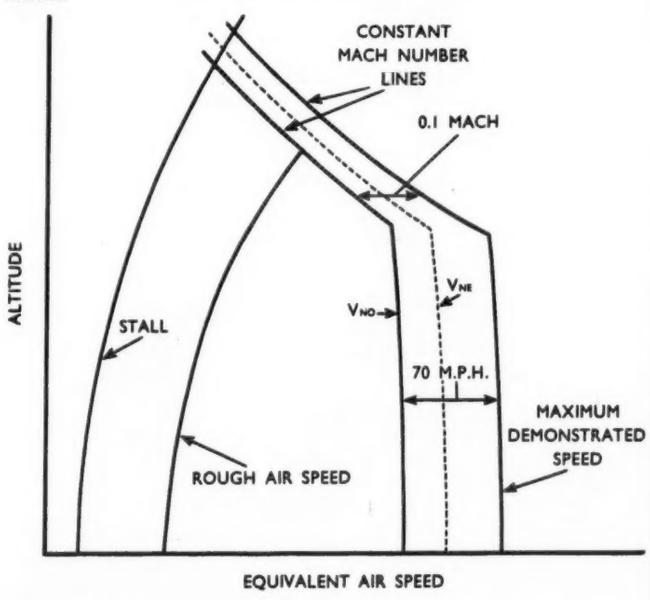


DIAGRAM OF OPERATING SPEEDS FOR A JET TRANSPORT AIRCRAFT

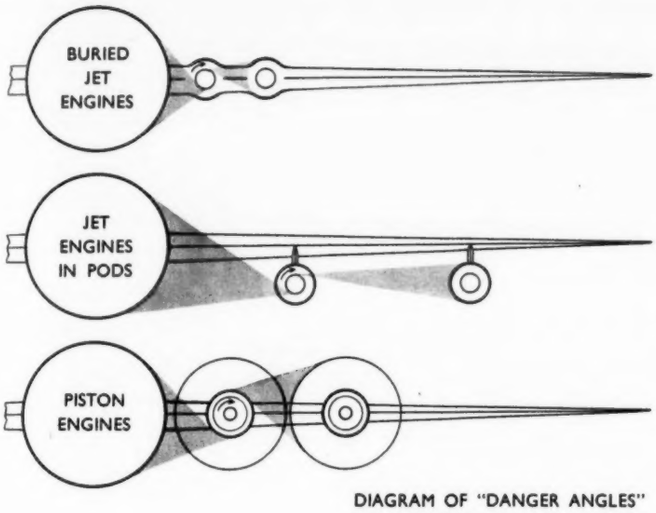


DIAGRAM OF "DANGER ANGLES" FOR DIFFERENT ENGINE LAYOUTS

Figure 2.

limit-speed" (V_{no}) at speeds lower than the maximum. For piston-engined aeroplanes flying at low altitudes, V_{ne} was conventionally set back 10%, and V_{no} was set back a minimum of 70 m.p.h., but these margins were in practice usually larger since economy generally dictated cruising speeds well below V_{no}. For the jet transport flying at high altitudes, all these higher speeds become functions of Mach number and the previously accepted margins no longer apply. It seems to have become generally accepted that a minimum margin of 0.1 Mach should be provided between the limit speed and V_{no}, but this has yet to be proved by operational experience, as we have not yet encountered a jet aircraft which was able to cruise at V_{no} all the time. Until this experience is obtained, provision of large dive brakes capable of being extended at any speed seems to be an essential safeguard.

A further complication arises over the determination of the limit speed itself. This speed must be approached with care in case of unexpected trim changes. The jet transport, due to its lower wing factors, is not in the happy position of the fighter aircraft which, due to its higher wing strength, is able to do the test at an altitude at which the high "g" stall will protect the wing against overstressing. The speed is often limited by the aerodynamic buffet which usually signifies the onset of compressibility effects; this buffet is a function of lift coefficient as well as Mach number. Thus the aeroplane weight for the test is important, since it is often quite easy to demonstrate a comparatively high Mach number at an unrepresentatively light weight. For this reason, among others, it is becoming necessary to control the altitude of cruise as a function of weight, and the whole certification process is tending to be tied to a cruising procedure which may soon become mandatory.

Rough Air Speed

For many years it has been normal practice to determine a "rough air speed" and to record it in the Flight Manual. This speed is worked out to give protection against gusts. At lower speeds there is a risk of stalling and at higher speeds there is a risk of structural damage if a gust of maximum vertical velocity should be met. A lot of research work has been done recently to determine how these gust velocities will vary with altitude. There comes an altitude, however, at which rough air speed becomes equal to V_{no} and, if extreme turbulence is encountered above this altitude, the only course open to the pilot would be to extend his dive brakes and descend rapidly. It seems probable that this altitude will have to dictate the start of the cruise and that any further increase in altitude will be associated with reduction in weight, and corresponding reduction in rough air speed, as the flight proceeds.

Performance

A careful analysis is of course needed of the performance of any transport aeroplane, and the jet is no exception. The most outstanding feature of the jet engine (and indeed of all turbines), from the performance point of view, is its sensitivity to the effects of ambient air temperature. It is therefore essential that temperature be taken into account as an operational parameter. This presents no difficulty using a performance code which makes proper allowance for the factors affecting performance, but an attempt to make arbitrary allowances may result in large losses in payload or in level of safety. It seems probable that the future will see jet transports which have a large surplus of climb performance because their engine power is dictated by cruising considerations and thus the scheduled take-off and landing distances become of even greater importance in determining take-off weights.

In relation to take-off, the acceleration at the point of unstick is normally large, even with one engine inoperative, and thus the speed at 50 feet inevitably exceeds that at the start of transition. It has become our practice to put in the Flight Manual a curve showing unstick speed as well as take-off safety speed as a function of weight; the former being determined from, among other things, consideration of "ground stalling" or drag rise at large fuselage attitudes as well as the normal safety speed criteria. In this way the safety speed used in the climb-away retains approximately the same margins above the power-on stalling speed as have been present on contemporary piston-engined aeroplanes. Further research is needed on this matter to determine a universally applicable safety speed criterion and this has been under active consideration for some time.

With the improvement in take-off performance, the importance of the landing as a factor affecting operating weights is rapidly increasing, and here the jet transport without reverse thrust is much worse off than its piston-engined counterpart, since its retardation is critically dependent on the functioning of the brakes and on the runway coefficient of friction. It has for some time been apparent that a new approach was needed to landing distance measurement, and the record of jet operations has already shown that, for this class of aircraft, a revision of requirements is essential.

Whilst on the subject of landing, I would like to sound a note of warning. In my opinion the behaviour of all jet aeroplanes on landing leaves much to be desired. Compared with the landing of a piston-engined aeroplane the technique which now appears to be normal for jet aeroplanes, in which the throttles are closed well back and the final stages made, in effect, power off, deprives the pilot of control of the approach gradient at a vital stage. I cannot help feeling that further attention is needed to this case. There is no doubt that the great majority of pilots find no difficulty in landing a jet, but for civil operation we are looking for a very high standard, and even the best pilot can be caught by an awkward wing gradient or by an inaccurate ILS beam. I would like to see either better response from small throttle movements at low thrusts or, if this cannot be done, then some form of air brake which can be used like a throttle in the final stages.

Fire

The use of kerosene as a fuel does not seem to have solved the fire problem, but what it has done is to reduce considerably the rate of spread of fire in a crash, and it thus gives those few vital extra moments which allow the occupants a better chance of escape. All the usual precautions are still necessary to prevent fire in the air and, if it does occur, to extinguish it. Kerosene seems to have a nasty habit of creeping into unexpected places and lying there without evaporating, so that ventilation is very important as a fire precaution. One promising solution to the problem of dealing with fires is to enclose the whole power plant in what is virtually a fireproof tunnel.

Engine Layout

In venturing to express some opinions on the safety aspects of buried engines versus engines in pods, I am well aware that opinion is sharply divided on the two sides of the Atlantic, and I may well be rushing in

where angels fear to tread. However, it is a controversy which must be resolved, and I feel that there is much merit in each layout, but in each case some very important safety steps are necessary.

To take the podded engine first, this layout may be criticised because of the high asymmetric thrust which can arise in the event of engine failure. However, this is an obvious one and is no doubt allowed for when considering the engine-out case and the landing with one and with two engines out. What concerns me more is the behaviour in a wheels-up landing or in a minor crash, and here it seems to me that there is a considerable risk of the engine coming up through the wing hot end first, and it is therefore to be hoped that this portion of the wing will not contain fuel. I believe that the proponents of the pod will claim that, in these circumstances, the pod is supposed to break off and get left behind, and that in fact it is designed to do so. It seems to me, however, that such a design may either require special precautions to stop the engine dropping off in the event of a fire in the air, or the wing will have to be strong enough and stiff enough to withstand the removal of this valuable relief load.

To turn to the buried engine, this should be very much better placed in the event of a minor crash, but criticism is levelled at it because of the greater danger of damage to the fuselage and other important structure in the event of a break-up of the engine in flight.

The answer of the proponents of the buried engine is that this risk must just be designed out. Break-up of the engine can be discussed under two headings. Firstly, blade failure. The chances of this are of course always present because of the possibility of stones or birds entering the intake. Luckily, however, the blade is fairly light and it is not a difficult matter to build sufficient "meat" into the engine casing to make sure it contains its own blades. Secondly, the question of wheel failure, and this is quite another matter. Due to the very large energy stored in it, a fracture of the turbine disc could cause a major disruption, and the disc must be made with sufficient strength to prevent such an occurrence. To those who may be sceptical about this I would point out that the risk already exists with propellers where the "danger angles" in the event of blade failure are not dissimilar (see Figure 2). From this point of view the turbine wheel seems to present a simpler design problem than the propeller.

To summarise, therefore, special precautions are needed in each case. In the case of pods, to guard against the engine entering a fuel tank in a crash and to guard against possible loss of an engine in flight. In the case of the buried engine, to guard against blade failure and wheel failure.

Other problems

In an article such as this, it is not possible to discuss any of our problems deeply, neither is it possible to mention them all. There are a number of operating problems, such as the rather complicated fuel use procedure, which come with the swept wing, the problem of preventing collision at high speed in the rather odd light conditions found at high altitude, and the need for more sensitive artificial horizons and for better navigational aids down the routes. I hope, however, that the few problems I have been able to mention will serve to justify the Board's stock question "What happens if . . .?" On the other hand I trust that the reader will not conclude from them that the numerous good features of this stimulating new advance are being overlooked. It is the business of the Board to keep pace with this advance by helping to solve the problems which are thereby presented and so to provide the safety which is rightly regarded as an essential background quality of air transport.

Finally, I would like to thank the Chief Executive of the Air Registration Board for permission to publish this article, and to make it clear that the opinions expressed are entirely my own.

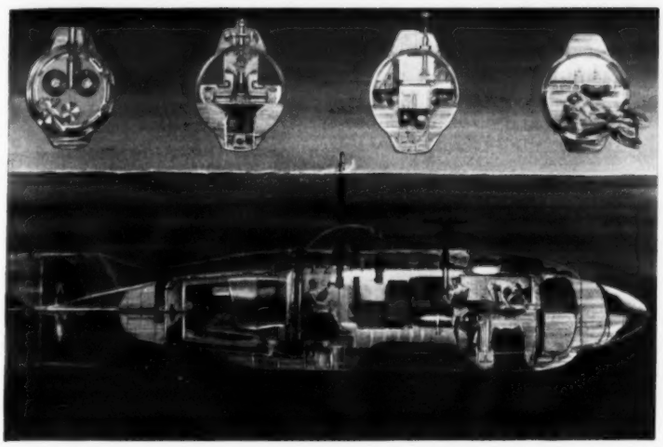
Wingless Jet Flight in 1975?

Attempts to discover the ideal solution of the vertical take-off and landing problem seem to be becoming nearly as numerous as the world's aircraft engineers. One of the more recent recruits to the VTO brigade is 61-year-old Dr. Alexander M. Lippisch, the German designer, who long ago pioneered the delta-wing aircraft and developed the Messerschmitt Me 163 rocket-powered delta-wing interceptor. Lippisch, now Director of Aeronautical Research at Collins Radio Co., Cedar Rapids, Iowa, is working on the development of what he calls the Aerodyne, a wingless aircraft using an "internal lift-inducing propulsion system" enabling it to rise and descend vertically, hover, and cruise like a conventional airliner. How the Aerodyne works is not disclosed, but it is thought that through an intake in the vehicle's nose air is fed to gas turbine engines, the gas jet of which is deflected downwards for vertical flight and hovering and ejected rearwards for level cruising. Collins Radio has been awarded a research contract by the Office of Naval Research and has built flying scale models to the designs of Dr. Lippisch. The latter is seen here testing two of the models, which seem to be powered by an electric motor and remote-controlled.

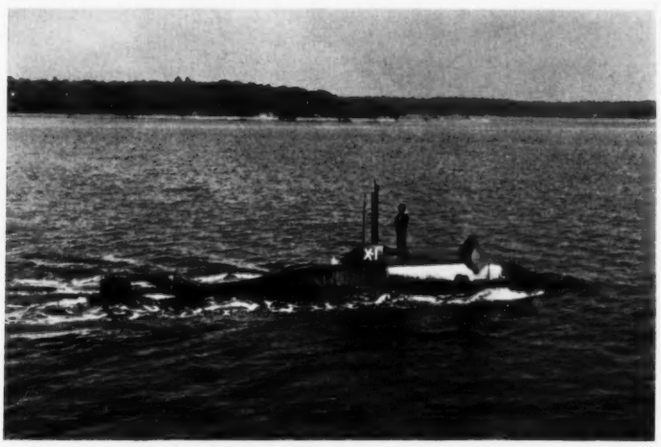
What full-scale Aerodyne *may* look like—circa 1975.

Dr. Lippisch and two of his Aerodyne models.

Fairchild Builds a Submarine



Cross-section drawings in the upper half of the picture show *(left to right)*: (1) View from cabin of engine bulkhead, with access doors and inspection windows; (2) looking aft towards dual control system and control console; (3) view of cabin forward from control position, showing oxygen storage, periscope, crew comfort equipment and communications racks; (4) underwater swimmer's tank and exit hatch with, above the tank, bunks for two of the crew.



The X-1 conducting trial runs in the waters of Long Island Sound. The "test pilot", now with Fairchild Engine and Airplane Corp., is William Rand, a former Lieutenant in the Navy's submarine service.

By way of contrast – the Navy's atom-powered submarine *Nautilus*, 1,500 tons, being loaded up with torpedoes.

From time to time it has happened that a shipbuilding company has entered the aircraft manufacturing business—Vickers and Blohm & Voss are two examples—but an aircraft manufacturer turning shipbuilder seems to be a much rarer occurrence. True, in the case under discussion the vessel built by the aircraft manufacturer is barely as large as a modern fighter fuselage and, moreover, it is a submarine.

The manufacturer is the Fairchild Engine Division of the Fairchild Engine and Airplane Corporation. The product is the Fairchild X-1, a midget submarine designed for close-in reconnaissance of harbours and inlets. This is the first "minisub" ever produced in the U.S.A., but while the German and British midget submarines in service at the end of the war carried crews of two or three as well as torpedoes, the X-1 carries four "frogmen" who are able to leave their boat through underwater hatches, swim under water with breathing apparatus to accomplish their missions (cutting of anti-submarine nets, testing of harbour defences, reconnaissance, probably sabotage and similar work) and return to their boat.

The Fairchild boat weighs only 25 tons, is 50 feet long and has a maximum diameter of seven feet. The company designed and built an "unconventional underwater propulsion system", details of which are not revealed but which enables the boat to operate quietly and stealthily, performing missions which larger craft could not. The X-1 is fully air-conditioned and temperature-controlled, power plant is separated from the cabin, and latest insulation techniques are employed to minimize noise level. In fact, the makers claim that the crew is just as safe and comfortable as that of large submarines. There is easy standing room, there are bunks, a reading table and even a miniature walkway. Adequate water and food storage is provided, as well as a hotplate for preparing warm meals, "easy-on-the eye" illumination and decoration.

The boat is designed so that it can be quickly assembled—or parts replaced—at the dockside or aboard larger ships; it can be transported, whole, overland by train or truck, whereas, disassembled into major components, it can be carried by air.

The submarine is fitted with "airplane-type" dual controls permitting one-man operation.

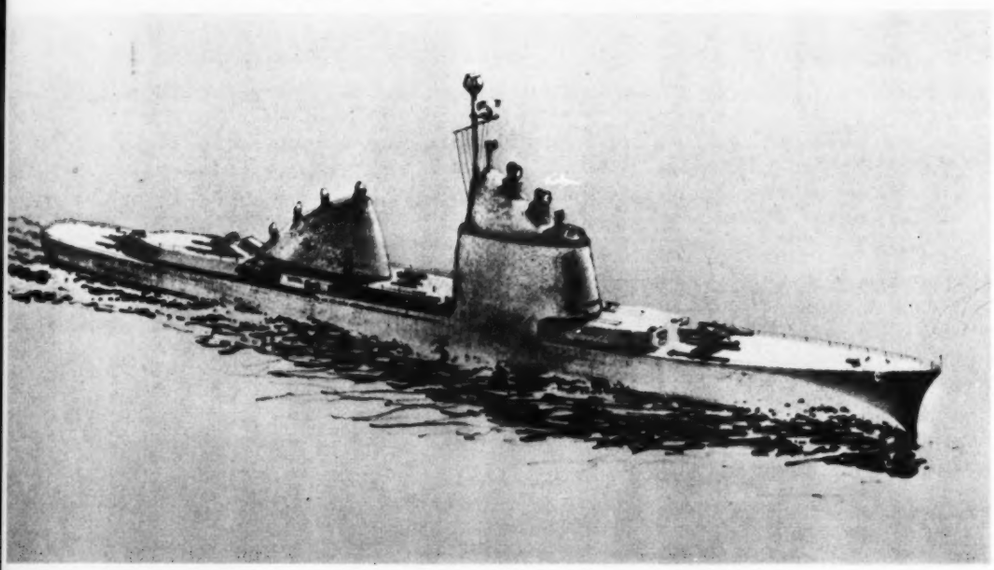
"The Last Weapon but One"

The May 1955 issue of *Interavia* was devoted to the subject of *guided missiles and rockets*. This was probably the first relatively complete compilation of released information on guided and unguided robot weapons. At the end of their introductory article the Editors reached the following conclusion: "To begin a third world war with thermonuclear long-range weapons would mean setting off a 'chain reaction' which would be bound to run completely wild. The rocket with an atomic warhead would in fact be the last weapon—bar one . . . the next and final weapon would surely be the stone-age club." Since then the same subject has been chewed over almost daily in the press, and it is striking that almost every news magazine in both Old and New World has taken it up during the past few months. Many of the writers, however, have made the mistake of confusing the unguided Intercontinental Ballistic Missile with guided missiles.

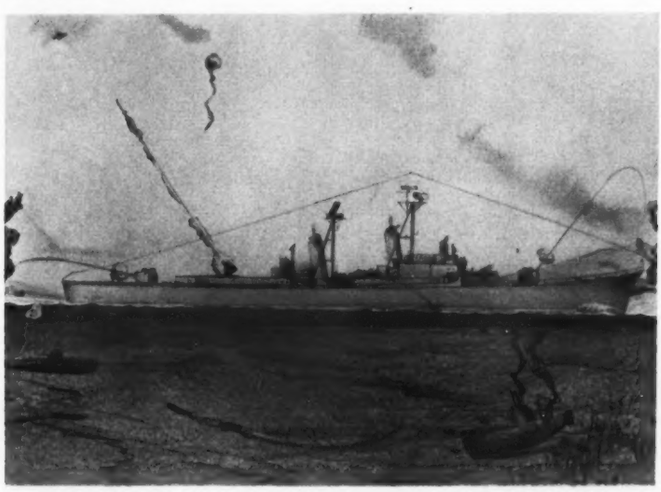
Meanwhile there are increasingly frequent reports that the Soviet Union is extremely advanced in the field of ballistic missiles. The Russians themselves maintain—and there is no information on which they can be contradicted—that American research and development has lagged behind. All this has caused some concern in Washington. While some described it as Russian bluff, others took the Russian reports dead seriously. The Democrats, with former Air Force Secretary Stuart W. Symington as their spokesman, accuse the Republicans in power of missing the boat and sitting back in unjustified optimism. In all objectivity, however, it must be admitted that U. S. research and development have by no means been idle, as is proved by a glance at the list of long-range weapons of all kinds on pages 306-7 of the May issue.

At the Pentagon it was the *Assistant Secretary of the Air Force for Research and Development, Trevor Gardner,* who was responsible for long-range weapon development, until he handed Air Force Secretary Donald A. Quarles his resignation on February 8th, 1956—a suprise only for the outsider. Differences of opinion

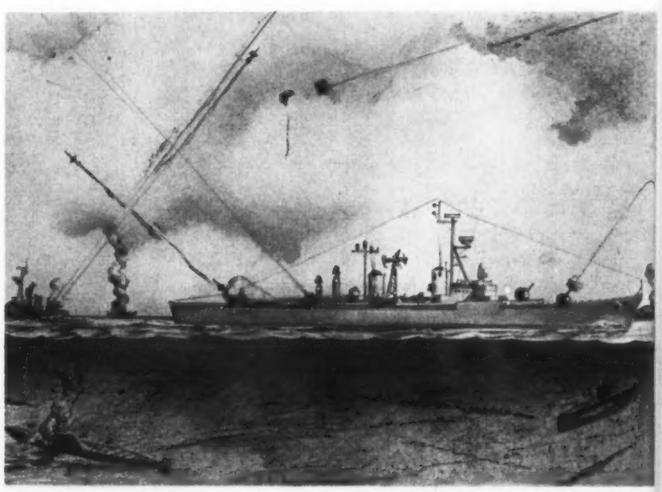
The most revolutionary ship planned by the U.S. Navy is the "Salu" type nuclear-powered guided missile cruiser which will combat sea, air, land and underwater targets. It will carry a number of multiple missile launchers for missiles of different range and capabilities, as well as torpedo-launching equipment.



The U.S. Navy's proposed 1957 construction programme includes this destroyer-class guided missile ship (DDG). It is to be "equally efficient against air and undersea targets" and will have greater over-all strength and sea-keeping qualities than the World War II types now in operation.



Another new addition to the U.S. Navy's fleet will be this frigate-class guided missile ship, which will carry surface-to-air and surface-to-underwater missiles and will also serve as an aircraft early warning post.



with the Secretary, what he considered to be inadequate appropriations for long-range weapons and delays in the execution of the long-range weapons programme are the reasons he gave. However, right from his appointment in the autumn of 1954, Trevor Gardner, the "prodigy" of America's long-range weapons development, had aroused controversy, and was not confirmed in his post until February 28th, 1955. As an arms manufacturer he had quickly risen to prominence at the head of his own Hycon Manufacturing Co., with connections reaching as far as Europe. By the time these lines appear in print Defense Secretary Charles E. Wilson will doubtless have appointed a new "*guided missile and rocket Czar*" with special powers, for this side of U. S. arms planning is becoming more and more important.

The *U. S. Navy,* too, is taking an increasing interest in these weapons. Its aim is to combine "atoms with atoms": i. e., *atom-powered ships and long-range weapons with atomic warheads.* In January 1956 the programme appears to have been approved in principle by the Congress, and the "last word" is now the development of *missile ships.* The three accompanying drawings depict this new class of ship.

*

Strangely enough a *Russian booklet* published by the Soviet Government in May 1955 under the title "*Thoughts on Air Strategy*" appears to have been generally overlooked or more or less ignored. Yet this 27-page booklet is said to have been distributed in 50,000 copies. Its author is believed to be the *Commander-in-Chief of the Red Air Force, Marshal Pavel Zhigarev,* who was promoted to Grand Marshal of the Soviet Union on March 10th, 1955. He is assisted by *Generals Rudenko and Sudets,* who were also promoted Marshals at the same time. The booklet was the first written statement by the Red Air Force command. Its main points are as follows:

Grand Marshal Pavel Zhigarev, Commander-in-Chief of the Red Air Force and author of the booklet "Thoughts on Air Strategy".

● *The strategic bomber is out of date.* Its development and production take too long and are too costly. In wartime, losses in both equipment and personnel would be unacceptably high. Another handicap would be the vast, over-complicated and easily vulnerable ground organization for the bomber, not to mention the logistics personnel and fuel stocks needed.

● *Intercontinental rockets or space weapons* (Russian designation SIG, roughly equivalent to the American ICBM) are *faster,* as well as *simpler* and *less costly* to develop and build. Their range is longer, their speed higher than those of the bomber. Their demands on ground personnel and on the ground organization as a whole are small, and their launching ramps can be camouflaged underground.

The Russian booklet culminates in a criticism of corresponding American development, which is said to be inferior. And the final sentence reads: "Today's giant air bases will become bomber cemeteries in a future war."

This throws some light on the West-East controversy on air strategy. There will be more to say on this subject within the near future.

CRUSADER AND CUTLASS

The U.S. Navy's latest fighter, a Chance Vought F8U-1 *Crusader* (foreground), in formation with a F7U-3 *Cutlass,* another carrier-based fighter built by Chance Vought for the U.S. Navy.

Successor to the Hunter

Background to the English Electric P.1

BY INTERAVIA'S LONDON EDITOR

One of the most important British military aircraft at present being developed is the English Electric P.1 twin engined interceptor. It is this aircraft which is expected to take over the burden of day and all-weather fighter defence of the United Kingdom after the present *Hunter* generation.

The P.1 is the first supersonic fighter to fly in the U.K., and it is also the first fighter designed by the English Electric Company, who have been responsible for one of the most outstanding British military aircraft since the war, the *Canberra* light bomber.

Initial design of the P.1 dates back seven years, and it embodies all the Air Ministry requirements in a specification for a home defence fighter. These requirements, due to the contrast in size and operational layout of the U.K. compared with the U.S.A., differ very considerably from the American idea of an air superiority machine.

By its very nature, the P.1 can be employed either as a short range "target-defence" type interceptor, using both turbojets with reheat for maximum rate of climb and speed, or as a long range patrol fighter cruising at altitude on one engine.

Twin engines were considered essential by the Air Ministry, and the problems of housing and of overcoming asymmetric thrust, while retaining a low frontal area, were solved by mounting the engines one above the other in the rear fuselage, fed by a single pilot type intake.

The P.1 had to have high speed (reports from outside the U.K. put this at Mach 1.5 plus) combined with good operational ceiling, manoeuvrability and landing and take-off characteristics. These combined were extremely difficult to obtain, but the company have succeeded by using a thin wing of about 60 degrees sweep, generous in area and with tips at right angles to the centre-line. Thus they have what is known in England as a "notched delta".

The three men chiefly responsible for the English Electric P. 1 fighter. *Left to right:* W. Shorrock, Manager of the Preston Works of E.E.C., where the company's aircraft are built; Wing Commander R. P. Beamont, Director of Flight Operations, E.E.C.; and F. W. Page, Chief Engineer of the Aircraft Division of E.E.C.

All controls are powered. For a machine of its size (length about 51 ft., and span about 36 ft.), the P.1 has exceptional take-off and landing characteristics. That it can operate out of present standard R.A.F. airfields is indicated by the fact that at the last S.B.A.C. display the aircraft was based on the nearby fighter station at Odiham.

The application of the "area rule" or "coke-bottle shape" to U.S. fighters has been much in the news lately, and examination of the P.1 design reveals that it conforms to area rule requirements.

The design task facing the English Electric Co. with the P.1 was so great that they embarked upon what is probably the most extensive private research programme ever devoted to a single British warplane. Three wind tunnels were used, a low speed tunnel built in 1948, two high speed tunnels and a water tunnel. The first of the high speed tunnels was completed in 1949 working up to Mach 0.95, but this was later modified to up to Mach 1.2, with a working section of 12 inches square. This was the first supersonic wind tunnel completed in Europe after the war.

The latest tunnel has a working section 18 ins. square and has been giving steady operation from Mach .45 to above 1.6 for some two years. The water tunnel with a 20 ft./sec. water flow has yielded valuable data at slow speeds.

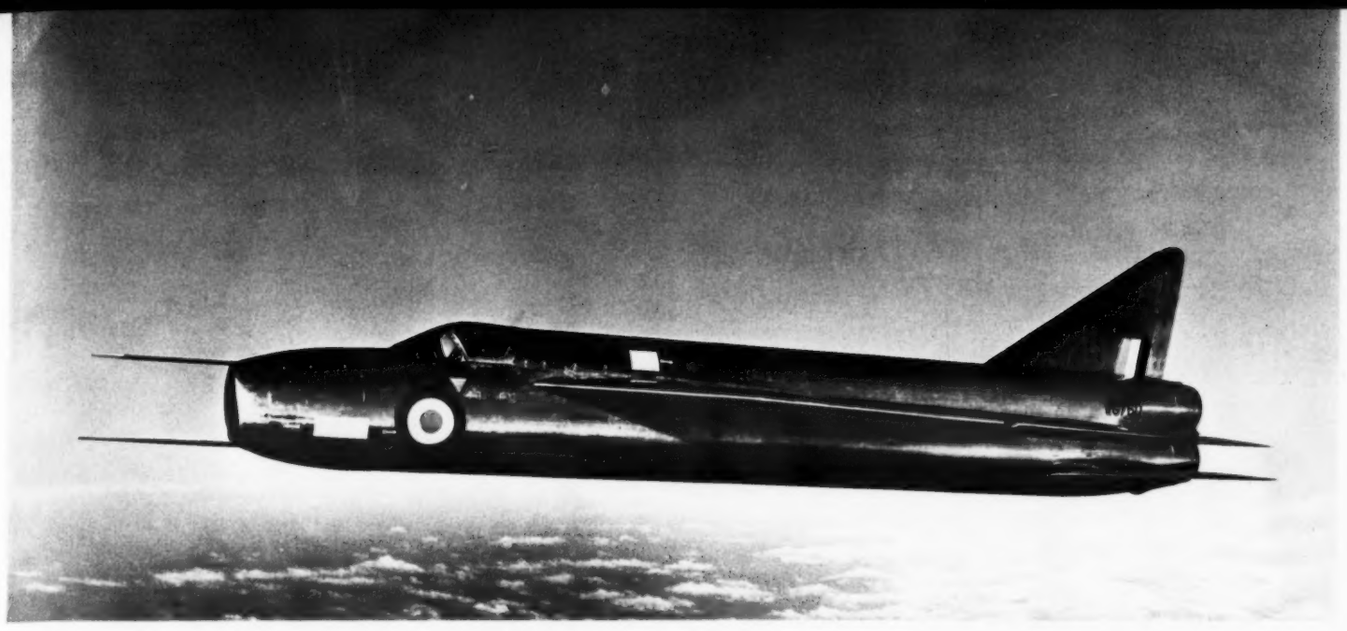
A very wide range of test rigs for the complex fuel system, tensile strengths, fatigue tests etc., were built. In addition, an analogue computer for solving flutter problems was built by the English Electric Nelson Research Laboratories at Stafford. This has been used in conjunction with a special flight simulator with a dummy cockpit.

English Electric's director of flight operations, Wing Commander Roland Beamont, was able to assess on the simulator the P.1's general handling characteristics long before the aircraft was first airborne.

To obtain practical experience on the P.1's slow-speed flying characteristics, the Ministry commissioned a scale flying model to be built by Short Bros. and Harland Ltd. Known as the SB.5, this aircraft has provided English Electric

The P. 1 comes in to land. Note flaps.

The P. 1 during a slow fly-past at Farnborough.



The P. 1

with invaluable data on slow speed flying with various degrees of wing sweep, and it has also been tested with the tailplane in high and low positions. At first, full span leading edge slats were to be used on the P.1, but flight trials on the SB.5 showed that much better results could be obtained by special modifications to the leading edge profile and drooping of the inboard leading edge. These ideas were satisfactorily demonstrated on the SB.5 with the result that the P.1 now has what is probably the widest fully controlled speed range of any supersonic fighter.

Among other unusual items on the P.1 are the main undercarriage legs which retract outwards into the wings, thus allowing maximum stowage inboard in the wing—presumably for fuel. The undercarriage itself, of British Messier design, utilises high pressure tyres. One undercarriage unit was in fact shown at the 1953 S.B.A.C. display, although not then labelled as such. The P.1's main wheels are fitted with Dunlop 33×6.75-20 tyres which carry a maximum dynamic load of 39,220 lbs. at 280 p.s.i. inflation pressure. The nose wheel, also by British Messier, folds forwards and turns through 90 degrees to lie flat, thus avoiding any obstruction in the intake.

The Short SB. 5, test vehicle for the P. 1. The inboard leading edge is drooped for low-speed trials. This feature has been incorporated in the P. 1.

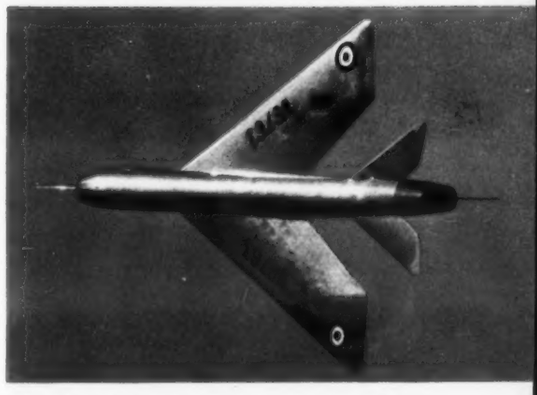
The P.1 flew for the first time on August 4th, 1954, and gave a foretaste of its capabilities by going supersonic there and then, and supersonic on climb on its third flight—both without afterburning. Since that time this machine and a second prototype have been exceeding the speed of sound in level flight and in climb with monotonous regularity. A third prototype P.1 is likely to appear shortly, and it is indicated that it will be a production prototype showing external signs of the equipment of its trade, i. e., electronics and armament.

Newspaper reports in the U.K. claim that this P.1 will utilise an advanced mark of Rolls-Royce *Avon* engine in place of the twin *Sapphires* at present fitted. It is further rumoured that the P.1 has considerable "built-in stretch" on performance and would prove a ready mount for a later combination of jet and rocket.

As the layout of the P.1 lends itself to the installation of either of the present two British single spool axials, the question of power on the production machines seems rather to depend on engine manufacturers' commitments and the Ministry of Supply delivery programme. Armament on the P.1 is stated to be "very heavy" and is likely to consist of a battery of 30-mm cannon and guided missiles.

Twenty pre-production P.1's are on order in addition to the five prototypes, and this will doubtless give English Electric the chance to build them in full production jigs.

Although no large scale order for the P.1 has yet been announced, the Ministry of Supply have made it clear that this is only a matter of time, and it may depend solely on final power plant choice. English Electric are well situated to construct a highly complex machine like the P.1 as they produce everything in quantity, from refrigerators and radios to atomic power station generators, and with their associated companies, Napier and Marconi, they cover practically every aspect of aircraft construction and equipment.



This shot illustrates the "notched delta" wing plan form of the P. 1, the sharply swept tail, wing-tip controls, twin jet pipes.

The Dick Kerr works at Preston, in combination with the final assembly line at Samlesbury, during the war built no less than 700 twin-engined Handley Page *Hampdens* and 2,500 four-engined *Halifaxes*. They have followed this, since the end of the war, with some hundreds of *Vampires* and *Canberras*—the latter, in B.6, PR.7, B.8 and PR.9 forms, at present filling the shops.

Research and test work is carried on at a separate establishment at Warton. The basic set-up for *Canberra* production will also be utilised for the P.1 and it should ensure a steady and speedy flow of fighters to the R.A.F. when the time comes.

Training the New Japanese Air Force

Major Suzuki, future jet pilot for Japan.

A little more than ten years since the last Japanese suicide fighters disappeared from the skies of the Pacific, Japanese pilots are again in active training—with the full approval and assistance of the Americans, their former enemies. At the end of 1955 a total of 2,500 Japanese pilots and mechanics had completed or were undergoing training in the United States, while others were receiving instruction from U.S. officers in Japan.

The scheme to train former Japanese military pilots on modern American aircraft in Japan started in November 1954. By October 1955 several classes of pilots had received their diplomas upon terminating their refresher courses, and on November 25th the first class of 13 Japanese pilots completed their jet-flying course on Lockheed T-33A trainers. They are now continuing their training to become instructors for the Japanese Air Self-Defense Force.

Under present plans the future Japanese air arm will not become a very large force, and the main responsibility for the air defence of the North Pacific will remain in the hands of the Far East Air Force of the U.S.A.F. By the end of the 1956-57 fiscal year the Japanese Air Self-Defense Force is to have a total strength of 15,000 men and 582 aircraft. Of the latter, 93 will be North American F-86F *Sabre* jet fighters, most of which will be built under licence in Japan.

The pictures on these pages show a former "Kamikaze" pilot, Major Suzuki, undergoing his jet training on a two-seater Lockheed T-33A.

Details of the engine used on the T-33 trainer are explained through an interpreter. Almost all of the instruction is given in English, however, and the trainees all study English as one of their courses.

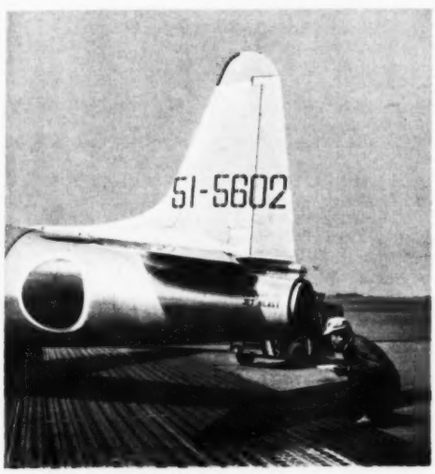
For one hour before flying an instructor—in this case Captain Ben Kimbrough, U.S.A.F. —goes over points which he thinks his students might need to brush up on.

Captain John W. Rakestraw, U.S.A.F., gives navigational instruction to Major Suzuki.

After the flight, Captain Oranges and his pupil fill in their flight log.

Flying Instructor Captain Chester M. Oranges of the U.S.A.F. and his student, Major Suzuki walk to their jet trainer.

Three student pilots carefully examine the two-seat cockpit of the T-33 they will eventually fly.

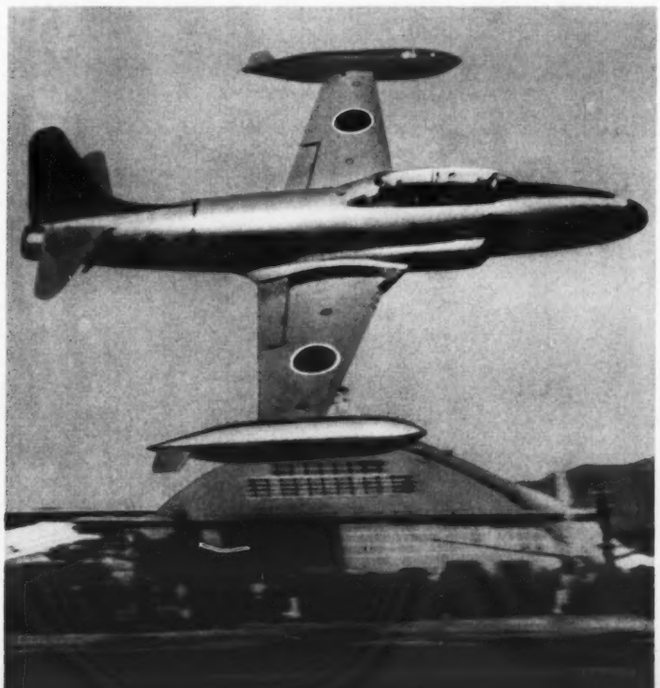


A mechanic checks the tail pipe of the T-33 (with engine off, of course!).

Upon completing its flight the T-33 lands. A Japanese ground crew man moves forward with the chocks.

Three laughing pilots of Japan's new Air Force hold their diplomas after graduating from their jet flying course.

The first Japanese-built jet: a Lockheed T-33A trainer assembled by Kawasaki Aircraft going through its paces early in January.



What's in the Air?*

AIR TRANSPORTATION

● **Scheduled air transport in the United States** has grown by almost 4,000 percent since 1938. Expressed in revenue ton-miles, traffic volume has risen from 58,112,000 in 1938 to 1,903,183,000 in 1954, an increase of 3,175 percent; expressed in passenger-miles, figures are: 1938 — 533,052,000; 1954 — 20,512,894,000, an increase of 3,740 percent. — During the same period railway freight traffic, for example, rose by 88%, car, truck and bus traffic by 97%. To ensure the further development of commercial aviation, A.T.A. President Stuart G. Tipton recommends that the entire American air transport industry be regulated and not just part of it.

● **Midway Field, Chicago,** the world's busiest airport, recorded roughly 8,752,000 arriving and departing passengers on scheduled air services during 1955, and 500,000 on non-scheduled services. Aircraft movements on scheduled services were 304,276, on non-scheduled runs 76,831; traffic at Midway in a single year was thus greater than that at London, Paris, Amsterdam, Copenhagen and Zurich combined. "Civil aviation in the United States is living in the 25th Century when compared with civil aviation in the rest of the world" is the conclusion reached by the Aircraft Owners and Pilots Association.

● **Eastern Air Lines** has won the struggle it has been waging with National Airlines since 1953 for the control of Colonial Airlines. The final decision was taken by President Eisenhower.

● **The growth of Spanish air transport** in the past 20 years is illustrated by the following figures: 1936— four airports, one airline with eight aircraft, seven domestic services, three international services; 1955 — 21 airports, two airlines with 48 aircraft, 29 domestic services, 14 international services, including four trans-Atlantic services. Spanish airports are today used by 23 foreign airlines.

● **Sabena** is following the example of Air France, B.O.A.C. and K.L.M. in seeking extension of its North Atlantic services to the U.S. West Coast. Final destination San Francisco. Negotiations are in progress with the U.S. and Canadian authorities.

● **New aircraft orders** are announced by K.L.M., Swissair and T.W.A. K.L.M. has increased its former order for eight Douglas DC-8s by an additional four aircraft of the same type and announced an option on ten Lockheed *Electra* turboprop transports. — Swissair has ordered two Douglas DC-8s. — T.W.A. has contracted for eight Boeing 707-120s and announced its intention of ordering a further 22 (some of them of the Intercontinental version) shortly.

● **Sabena traffic figures** for 1955 show an increase of 14.2% compared with 1954. Tonne-km offered 133,155,331 (121,849,431); tonne-km performed 94,897,874 (83,081,515). Aircraft-km 29,589,230 (28,090,355); passengers 449,698 (391,756); freight 25,037,216 tonne-km (22,410,496); mail 5,235,232 tonne-km (4,258,587).

One of the U.S. Air Force's weather balloons that are used for meteorological investigations in the stratosphere. The balloon is filled with hydrogen through the thin pipe. The cables carry cameras and radio transmitters.

● **Helicopter services** from Brussels to Paris, Luxembourg and Saarbrücken are planned by Sabena. Flying time Brussels-Paris 1 hour 45 mins. In the French capital helicopters will land at the Issy-les-Moulineaux airport, whence the city centre can be reached in a brief half hour.

INDUSTRY

● **Development and construction of atomic reactors** cost the United States Government a total of $ 62,300,000 during the second half of 1955. According to an Atomic Energy Commission report to Congress, first tests with an atomic power plant for aircraft have already been made (on the ground), and plans have been worked out for atomic power plant for a cruiser and an aircraft carrier. — Since the Atomic Energy Act was modified in 1954 agreements have been signed with 27 countries for the exchange of scientific information.

● **Higher defence spending** on flying equipment and guided missiles is forecast by Hall L. Hibbard, Vice-President, Engineering of Lockheed Aircraft Corp.: $ 9,000,000,000 by 1960 and $ 14,000,000,000 by 1970.

● **Lockheed Aircraft Corp.** plans to build a number of research laboratories near Palo Alto, California, for scientific research in the field of guided missiles and pilotless aircraft. The whole guided missiles division may later move over to Palo Alto from Van Nuys. Removal and expansion of the division is expected to cost around $ 20,000,000 in three years.

● **Boeing Airplane Company** is dividing its Seattle aircraft manufacturing operations into two new divisions, the Transport Division and the Seattle Division. The former will be responsible for the Model 707 commercial transport projects, the KC-135 tanker transport (military version of the 707) and the KC-97 tanker transport (military version of the *Stratocruiser*). The Seattle Division will handle the B-52 heavy bomber programme and major developmental projects.

● **Fairchild Aircraft Division** of Fairchild Engine and Airplane Corp., Hagerstown, Md., has opened a European Office in Geneva, Switzerland.

● **Thirty Fokker Friendships** have so far been ordered from Fairchild Engine and Airplane Corp., who is to build the Dutch aircraft under licence as soon as final details of the agreement have been settled. Orders have been placed by Mackey, Bonanza, Mohawk and West Coast Airlines, who have also announced options on another ten *Friendships*. According to unconfirmed reports, European airlines have also ordered 25 *Friendships*.

● **Douglas Aircraft Co.** estimates that its profits for the 1955 business year to November 30th will amount to $ 28,250,000 ($ 7.66 per share), compared with $ 36,100,000 ($ 9.80) the previous year. Sales:

* Extracts from *Interavia Air Letter*, daily international news digest, in English, German and French. All rights reserved.

The signing of Sabena's order for four Boeing 707-320 jet transports was the occasion for a celebration at Brussels Air Terminal. Left to right: Operations Manager Anselme Vernieuwe, Legal Adviser René Golstein, Wellwood E. Beall, Senior Vice-President of Boeing Airplane Co., Gaston Claeys, Sabena Board member, Marcel Malderes, Sabena Board member, Laurence E. Peters, of Boeing's Sales Division. Other aircraft on order for Sabena are twelve Convair 440 *Metropolitans*, eight Sikorsky S-58 helicopters and nine Douglas DC-7C *Seven Seas*.

J. van der Wiel has been appointed Executive Vice-President of K.L.M. He has been with the company since 1938, initially as legal adviser, later as head of the Coordination Bureau and finally as General Secretary.

Lucien Servanty, S.N.C.A. du Sud-Ouest Chief Engineer and "father" of the SO.6000, 6025 and 9000 *Trident*, has been made Officer of the Legion of Honour.

Major General Gerald Joseph Higgins, director and adviser to the recently founded Piasecki Aircraft Corporation, Philadelphia (not to be confused with Piasecki Helicopter Corp., Morton, Pa.).

D. Napier & Son Ltd., Luton Airport, Beds., has equipped a Convair-Liner 340 with 3,500 h. p. *Eland NEl. 6* propeller turbines for experimental purposes. An extensive test programme is to be carried out with the *Eland-Convair*.

$ 876,000,000 ($ 915,216,000). Order backlog on December 31st, 1955 totalled $ 2,138,000,000 ($ 1,964,000,000).

● **Bendix Aviation Corp.** announces a record profit of $ 25,888,590 ($ 5.66 per share) for the business year to September 30th, 1955, compared with $ 25,537,771 ($ 5.62 per share) the previous year. Sales and other operating revenue: $ 567,249,923 ($ 607,711,607). The slight drop in defence contracts was partially balanced by an increase in the output of aircraft and vehicle accessories. Government orders accounted for 60 % of total production. Order backlog at September 30th, 1955, stood at $ 480,000,000 ($ 497,000,000).

● **Lear Inc.** reports an order backlog as of December 31st, 1955, of $ 53,459,922 an increase of 41 % over the figure for December 31st, 1954.

● **Rolls-Royce** recently delivered its last piston engine, a *Griffon*. It is to be fitted in an Avro *Shackleton* for the South African Air Force. Since first going into aero engine production in December 1915 Rolls-Royce has built 51,169 piston engines.

● **Hawker Siddeley Nuclear Power Co. Ltd.** is the name of a company founded by the Hawker Siddeley Group to build a nuclear research station.

SERVICE AVIATION

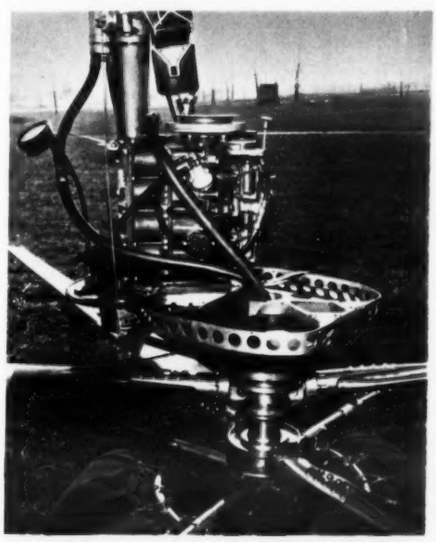
● **Jet aircraft noise** in the neighbourhood of United States airports and Air Force bases has been the subject of complaints by a number of Congressmen. The aircraft industry and Air Force have been called upon to take steps to reduce the noise nuisance. "If sonic boom from jet planes breaks your windows, don't write to your Congressman. Complain to the Air Force," a Congressman advised his constituents. — Meanwhile a bill before Congress seeks to bar jet aircraft from airports in densely populated areas by raising the visibility minimum for four-engined aircraft from 200 to 600 ft.

● **The fuel consumption of jet aircraft** may become a serious problem for the United States in the near future. Almost nil ten years ago, it is estimated by the Petroleum Logistics Division, U.S. Air Force Headquarters, at 231,000 barrels a day for military aircraft and 12,000 barrels a day for civil requirements in 1956. The corresponding estimates for peacetime consumption in 1965 are 340,000 and 70,000 barrels daily.

● **The South African Air Force** is to be modernized this year at a cost of £ 10,000,000. The programme includes the development of a radar network and introduction of thirty *Orenda*-powered Canadair F-86 *Sabres*, replacement of the *Sunderland* flying boats by Avro *Shackleton Mark 3s* and use of helicopters for rescue work.

● **The Japanese defence budget** earmarks 10,200,000,000 yen for defence contracts; 4,630,000,000 yen for the production of 180 F-86F jet fighters, 180 T-33A jet trainers, 22 T-34 trainers and four helicopters; 1,270,000,000 yen for repairs and 4,290,000,000 for arms and ammunition.

The U.S. Army has purchased twelve de Lackner *Aerocycle* one-man helicopters for experimental purposes. They will be subjected to through operational testing. — Power is supplied by a 43 h. p. Mercurey outboard motor boat engine. Speeds of around 60 m. p. h. and ranges of up to 150 miles are claimed. A payload of 300 lbs. can be carried.



● **Guided missile production** is among Japan's plans for the 1956-57 fiscal year. The Defence Ministry's Technical Research Institute is to have a guided missiles division for this purpose.

● **An airport bill** has been submitted to the Japanese Parliament. It provides for a total of 100,000,000 yen to be spent during the current year on repair and expansion of airports. — Among the 94 Japanese airports and landing grounds, all of which date from before World War II, 17 have been repaired or enlarged by the U.S. Air Force. The repair of war damage to the remaining 77 is expected to take five years and cost 10,000,000,000 yen.

● **Yugoslavia** is to get F-86 *Sabre* jet fighters from the United States under the arms aid agreement. The fighters will come from stocks which the Royal Air Force returned to the U.S. Air Force last summer. The number involved has not been revealed.

● **A rocket regiment** is to be set up in the West German forces to test modern guided missiles and train guided missile specialists. The regiment will be equipped initially with American guided missiles. Later rockets and guided missiles will also be issued to a number of anti-aircraft and anti-tank units.

● **The N. A. T. O. forces** will have seven squadrons of North American F-100 *Super Sabres* in place of the present seven F-86 *Sabre* squadrons before the end of the summer.

FLYING EQUIPMENT

● An order will shortly be placed for a new *multi-purpose turboprop freighter-passenger transport* for R.A.F. Transport Command. The aircraft will be capable of handling heavy freight and vehicles and is likely to have relatively high performance. It will perform duties at present done jointly by the Vickers *Valettas* and Handley Page *Hastings*. According to reports from London, Short Bros. and Harland is working on a project for a transport of this class. David Keith Lucas, Director and

Vickers-Armstrongs N. 113 twin-jet Navy fighter, a substantial number of which have been ordered for the Fleet Air Arm. Power plant: two Rolls-Royce *Avon* turbojets.

The U.S. Air Force's Lockheed C-130A *Hercules* transport with four 3,750 e.h.p. Allison T-56 turboprops, whose take-off weight is 108,000 lbs.

Assembling the Bristol *Britannia* at Short Brothers & Harland Ltd., who is sharing with Bristol in production of this type.

Chief Designer, states that the aircraft envisaged by his firm would have two propeller turbines of approx. 4,000 h.p. each, have a particularly flexible layout and be in the *Viscount* class as regards performance. — It has not yet been decided which firm will get the development contract, though Short seems to be under consideration.

● Changes have been made in the designations of the various versions of the *Bristol Britannia* turboprop commercial transport. New series numbers are as follows:

Former series number	New series number
Britannia 100	Britannia 100
Britannia 300	Britannia 300
Britannia 300 LR	Britannia 310
Britannia 250 LR	Britannia 250

Within each series, the aircraft ordered for particular operators are given individual variant numbers:

Series	Operator	Variant number
Britannia 100	B.O.A.C.	102
Britannia 300	B.O.A.C.	302
Britannia 310	B.O.A.C.	312
Britannia 310	El Al	313
Britannia 310	C.P.A.L.	314
Britannia 250	Ministry of Supply (for Transport Command)	253
Britannia 250	Ministry of Supply (for independent operators)	252

● The gross weight of the *McDonnell F-101A Voodoo* all-weather fighter is roughly 20 tons.

● The *Vickers Supermarine N.113* high-performance Navy fighter began flight testing at Boscombe Down on January 20th. Two Rolls-Royce *Avons* of one of the latest marks are fitted; wing sweep approx. 40°; span 38 ft. 6 ins.; length approx. 55 ft. Armament will be 30-mm Aden cannon plus guided missiles.

● Good progress is reported on the *Aviation Traders Accountant* twin-engined short and medium stage commercial transport. Flight testing is scheduled to begin early this summer.

● A prototype of the *Ambrosini-Aerfer-Stefanutti Sagittario 2* light-weight fighter with Rolls-Royce *Derwent* turbojet began taxi tests at Pomigliano d'Arco in February; flight testing is to be made at Pratica di Mare Air Force base (southwest of Rome). — In its present version the *Sagittario 2* is designed as a day interceptor, though a second version—fitted with Microlambda fire control radar—is to be developed for all-weather operations. A third version, a fighter-bomber, is also under consideration.

● A *Nord Noratlas* transport built by France's *S.N.C.A. du Nord,* fitted with Pratt & Whitney R-2800-CB.17 engines of 2,500 h.p. each, has begun flight testing. The *Noratlas* normally carries two Bristol *Hercules* engines (S.N.E.C.M.A. licence). Type designation of the version with P&W engines: *Nord 2503.*

● A first civil version of the *SE.3130 Alouette II* helicopter of *S.N.C.A. du Sud-Est* (with Turboméca *Artouste II* turbine) will be taken over by Electricité de France next July. S.N.C.A.S.E. has taken extensive measures to speed up deliveries of the production *Alouette.* The French Navy has also ordered helicopters of this type.

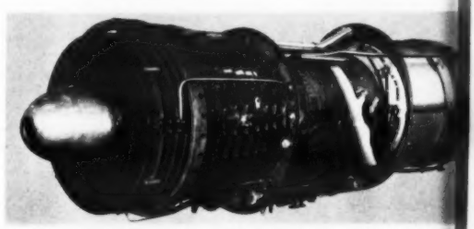
● *Chance Vought* is working on the development of a U.S. Air Force version of the *F8U-1 Crusader* carrier-borne fighter.

● *Piasecki Aircraft Corp.* is working on a project for an aircraft with extremely short take-off and landing runs. The company's programme also includes development of a heavy helicopter and a convertible aircraft.

● The giant *Douglas XC-132* transport (gross weight roughly 180 tons!) is still in the mock-up stage. It will probably be several years before a prototype is built.

● Flight testing of a second prototype of the *Republic F-105* jet fighter has begun at Edwards Air Force Base, California. The first prototype was lost about three months ago when the undercarriage failed.

● Kaman Aircraft Corp., of Bloomfield, Conn., has received a *development contract for an annular wing aircraft* (coleopter) from the Office of Naval Research.



Bristol *Olympus BOl.11,* the latest version of the two-spool turbojet, has been certificated for a take-off thrust of 12,000 lbs. after completion of a 150-hour test.

● *Temco Aircraft Corp.,* Dallas, Texas, has brought out a new two-seat all-metal low-wing monoplane, the *Model 58,* for elementary training: retractable nose-wheel undercarriage; 340 h.p. Lycoming GSO-480-A1A engine; a big variety of military loads (machine guns, bombs, rockets, napalm containers) can be carried for practice purposes. — Span 33 ft. 2.6 ins., wing area 156.83 sq.ft., gross weight (without armament) 2,993 lbs. — Max. speed 185 knots at 10,000 ft., cruising speed 174 knots, service ceiling 25,000 ft., range 485 nautical miles.

The Douglas C-133A transport with four Pratt & Whitney T-34-P-3 turboprops of 6,000 h. p. take-off power each. Span 179 ft. 8 ins., engtth 148 ft. 2 ins., gross weight 255,000 lbs.

POWER PLANT

● The *Napier Oryx* gas generator has completed a 150-hour run at 780 gas h.p. The *Oryx* is thus the first British turbine engine to be certificated for use in helicopters.

● In France a turbojet of the *Turboméca Gabizo* type has also carried out a 150-hour test under I.C.A.O. regulations. Thrust measured 2,425 lbs. (take-off power) and 1,980 lbs. (max. continuous power). — Weight roughly 550 lbs., including oil tank, starter generator and accessories drives.

● A new *Allison* turboprop, the *550-D.1,* will be of the two-spool type and be in the 5,500 h.p. power class.

Bendix International in Aviation

The part of Bendix in the technical progress of aviation is vast and varied. Because Bendix has always anticipated aviation's next advance, every plane that flies, in some way, relies on Bendix Creative Engineering.

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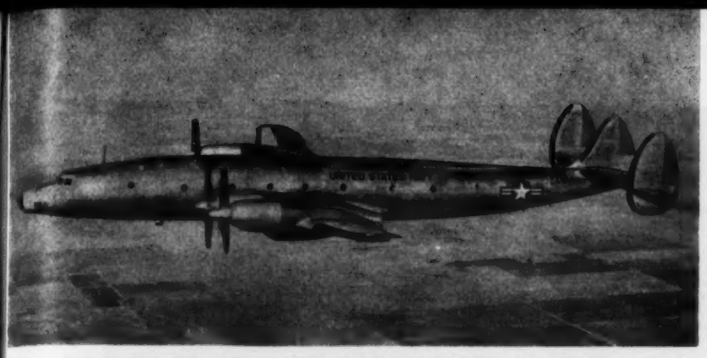
America's first prop-jet airliner ... first prop-jet combat transport ... fastest propeller-driven airliner ... first carrier-based jet trainer ... and world's fastest jet fighter—all are in production today at Lockheed.

Lockheed designed and produced the first operational jet airplane in the U.S. more than ten years ago. Since that historic day, Lockheed has built over 7,000 jet-powered airplanes—more than any other company in the world.

Lockheed's latest proof of leadership is the exciting new Lockheed Electra—*America's first prop-jet airliner*—now in production for delivery to the world's leading airlines.* In the pace-setting Electra, surging jet power is combined with proven propeller dependability and economy—to whisk passengers to their destinations in luxurious comfort and quiet up to 100 miles per hour faster than any airliner presently in service!

* Already purchased in quantity by American Airlines and Eastern Air Lines.

C-130 HERCULES, NEW PROP-JET COMBAT CARGO PLANE—Husky brother of the Electra. A 62-ton carryall, to transport men and materiel farther, faster and at less cost than any other plane! Now in production at Lockheed's Georgia Division, U.S. Government Aircraft Plant No. 6 at Marietta. As shown, a huge 5,000-gallon gasoline tank-truck can be driven up the ramp into the cavernous interior of a C-130.



NEW JET-POWERED VERSION OF SUPER CONSTELLATION. Achieved by substituting prop-jet power for piston engines—a remarkable increase-in-speed transformation made possible by the extremely rugged construction and advanced basic design of the time-tested Lockheed Super Constellations. Result: the fastest propeller-driven airliner in the world! Designated the C-121F by the U.S. Air Force, and the R7V-2 by the U.S. Navy, these prop-jet Super Constellations are now undergoing exhaustive official tests.

T2V-1, FIRST CARRIER-BASED JET-POWERED TRAINER Evolved for the Navy from a series of jet planes inspired by the renowned Lockheed F-80 Shooting Star of 10 years ago. The Lockheed T2V-1 (above) has won deserved acclaim as the world's safest jet airplane.

F-104, STILL-SECRET SUPERSONIC JET-POWERED FIGHTER. (Photograph not yet released.) A high-ranking USAF officer said of the F-104, "This is a fighter pilot's dream. We feel confident that it is the fastest, highest-flying fighter in the air, anywhere."

THE BRIGHT FUTURE OF FLIGHT. Virtually no limit is in sight as to speeds, distances and economies which will be possible in tomorrow's air travel. Rocket power, ram-jet engines or nuclear energy will thrust transports around the world at incredible speeds while passengers enjoy undreamed-of comfort. At Lockheed's Missile Systems Division and at other Lockheed research centers, scientists already are deeply engaged in projects involving these and other new sources of power for future flight.

104 ELECTRAS
have been ordered by
American Airlines
Braniff International Airways
National Airlines and
Eastern Air Lines

Lockheed

AIRCRAFT CORPORATION

California Division, Burbank, Calif.
Georgia Division, Marietta, Ga.
Missile Systems Division, Van Nuys, Calif.
Lockheed Air Terminal, Burbank, Calif.
Lockheed Aircraft Service, Burbank, Calif.

LOOK TO LOCKHEED FOR JET LEADERSHIP, TOO

THE VERSATILE

Pembroke

(Powered by two 550 h.p. Alvis 'Leonides' engines)

The Pembroke is in service with the Air Forces of

- *Great Britain*
- *Rhodesia*
- *Belgium*
- *Sweden*
- *Finland*

Some of the primary functions for which this versatile, sturdy and economical aircraft is basically equipped are the following . . .

10 Passenger communications
Freight and supplies dropping
Ambulance for 6 stretcher patients
Aerial survey and photography
Twin engine pilot training
6 seat V.I.P. transport

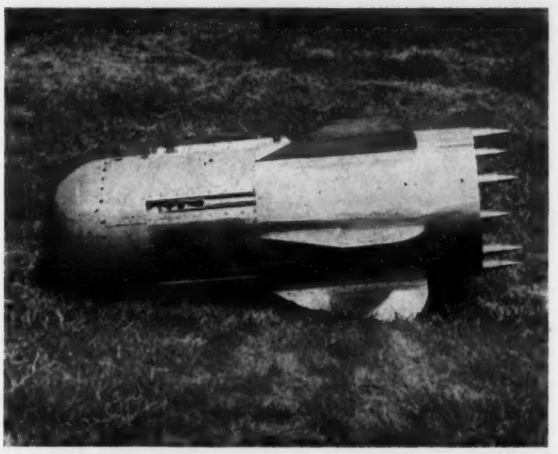
The Pembroke is also adaptable as a flying classroom for navigation, bombing and radio training.

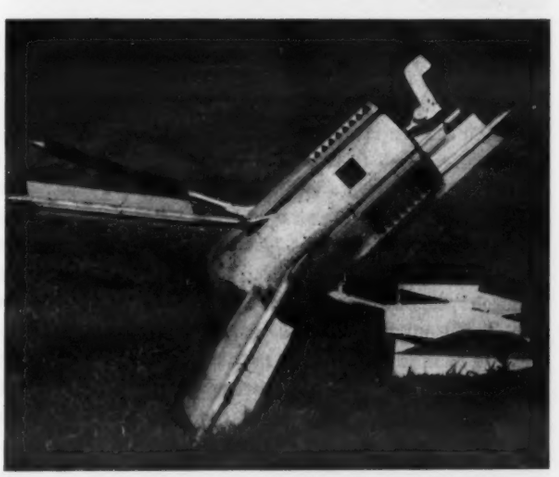
HUNTING PERCIVAL AIRCRAFT LTD

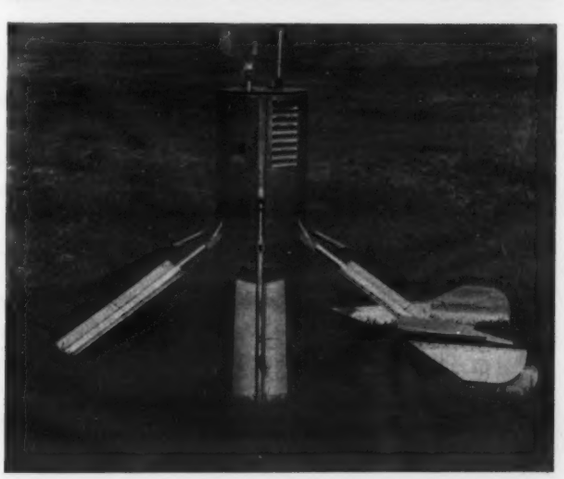
A Hunting Group Company

LUTON, BEDFORDSHIRE, ENGLAND and at 1450, O'CONNOR DRIVE, TORONTO, CANADA

Grasshoppers for the Antarctic







Meteorological services' synoptic weather charts still show many blank areas for which no meteorological values are obtainable. These areas are particularly large in the region of the earth's two Polar caps, above all in the Antarctic. Whereas, because of its decisive importance in all weather analyses and forecasts in the northern hemisphere, the North Pole region is flown over regularly by the U.S. Military Air Transport Service's meteorological aircraft and boasts several permanently manned observation stations (in northern Canada, Greenland, northern Siberia, etc.), a similar service is almost entirely lacking in the South Pole region.

When the U.S. Navy was planning its four-year Antarctic expedition (" Operation Deep Freeze "), it examined ways and means of improving the weather service so important to both flying and ground operations. One result of these efforts is the fully automatic " *Grasshopper* " *weather station* for release from aircraft shown on this page.

The " Grasshopper " (" ice-hopper " would perhaps be a more appropriate name) weighs only 200 lbs., i.e., as much as a parachutist, and is dropped from aircraft by parachute at " strategic " points where valuable meteorological data can be obtained. After landing, the parachute is automatically cut adrift from the station by the landing impact, and the station remains in place. Then mechanical devices on the streamlined legs come into operation. They move all six legs through an angle of roughly 120 degrees and set the body of the station up on its rounded nose, roughly vertical to the ground. The station is now ready for operation. A clockwork mechanism starts up and causes the built-in measuring instruments to record all important meteorological data at exact, predetermined times: surface wind force and direction, air temperature, barometric pressure and air humidity. These values are automatically fed to a coding device inside the station and broadcast by a radio transmitter in Morse code at the rate of 17 words per minute. Power is supplied by a battery with a working life of up to 60 days.

Maintenance units arriving at the robot weather station can exchange or recharge the batteries as required, or alter the time schedule for measurements. The stations are, of course, also suitable for manned operation, when they can be switched on or off to ensure optimum utilization.

The high military value of the new invention is also obvious. In more or less peaceful times, of course, meteorological organizations in East, West and neutral centre work together in exemplary fashion, exchanging their weather information by telegraph or teleprinter. In the event of war, however, the situation would change abruptly, and the ability to set up an almost self-supporting weather observation network—at least for brief periods—in inaccessible enemy regions must be extremely attractive.

The " Grasshopper ", top to bottom: landing position after automatic release from parachute; the six supporting legs begin to open; the robot weather station erects itself; ready for action. *Official U.S. Navy photographs.*

Dectra - for the North Atlantic

BY HOWARD CAPES, THE DECCA NAVIGATOR COMPANY, LTD., LONDON

Air traffic over the North Atlantic has suffered for a considerable time from the inadequacy of existing navigation aids. Today, when transatlantic flights peak to 3,000 per month, there are at any time of the day or night some 75 aircraft airborne between Newfoundland and the coast of Britain, all depending on astro or, when the sky is obscured, on hopelessly inadequate navigation aids. The result is that at present the separation standards of 120 miles lateral separation, 1,000 ft. of vertical spacing and up to 30 minutes longitudinal separation impose such restrictions on air traffic that costly delays are a regular occurrence, a state of affairs not likely to be improved by the introduction of jet aircraft into the traffic complex. Every day aircraft are held for long periods on the ground waiting for take-off or in the air awaiting their turn to be filtered into the terminal area. For similar reasons aircraft en route are often obliged to maintain uneconomical altitudes and at times even undesirable tracks. When it is remembered that the cost of one hour's non-productive flying is of the order of £350 it will be appreciated that the need for an accurate and flexible navigation system over the North Atlantic is acute. This requirement has been appreciated by the operators and the ministries concerned in Great Britain, and as a result of a careful examination of the problem official support has been given to the Dectra System which has been selected as the system most completely answering the requirement.[1]

*

The Dectra System is a radio position fixing device designed to cover specific air route sectors, in particular long transoceanic crossings. The system is based on Decca Navigator techniques, and there are great economic advantages derived from the fact that the airborne equipment can operate either on Dectra or standard Decca. Dectra requires Master-Slave pairs of transmitting stations, operating on *identical* frequencies in the 70 kc/s band, at each end of the route covered, each pair of stations providing a tracking facility from a stable hyperbolic pattern laid along the track, while a combination of the transmissions from one station of each pair provides a ranging facility from a hyperbolic pattern across track. For the North Atlantic route one pair of stations is located in Scotland to serve Prestwick, the other pair in Newfoundland serving the Western terminal, Gander.

1 Cf. " Radio Aids for Long-Distance Navigation ", *Interavia*, No. 6, 1954, p. 377.

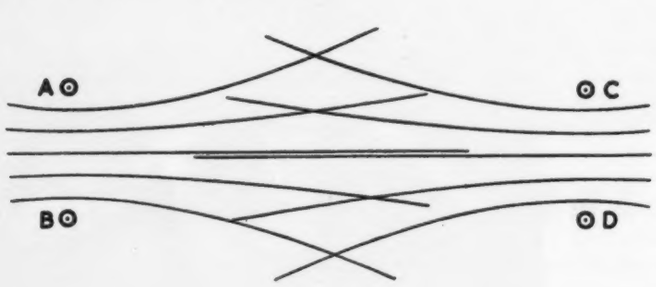
Fig. 1: Diagram of the two station pairs for Dectra, comprising one Master and one Slave station at each end of the route. The Great Circle route runs at right angles to the two base lines AB and CD. The latter are approx. 80 nautical miles long, and the route between them 1,500 to 2,000 nautical miles.

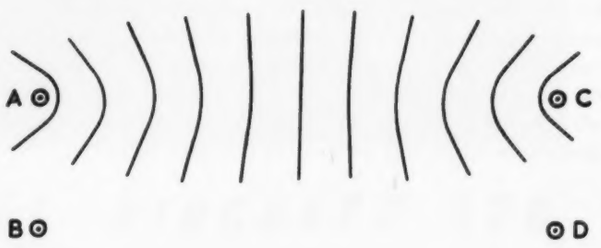
A ranging accuracy of 10 miles or better by night is predicted for the full length of the North Atlantic route, the accuracy of tracking is estimated at 5 miles over most of the route length, rising to a very high order of accuracy as the terminal is approached. It is interesting to note the correlation of system errors ; aircraft flying in the same area are subject to the same variations in the transmission of the signals, hence their relative accuracy is extremely high. Bearing in mind the overall accuracy of the system, lateral separation of 2 miles between aircraft in the terminal areas, becoming not worse than 30 miles in mid-Atlantic, can be achieved. These predicted figures are the results of long and detailed practical investigation into the reception of existing Decca Navigator transmissions at very long ranges.

To meet the worst possible combination of propagation and reception conditions there are two ranging systems incorporated in the Receiver ; one uses the very accurate hyperbolic pattern dependent upon the reception of two signals from sources at extremities of the route, the other depends upon the reception of signals from one (generally the nearer) source only and on the stability of the divided output of a crystal oscillator. The combination of these two automatically switched circuits ensures that the equipment will remain in operation throughout the route under the worst possible conditions. The two pairs of stations produce their respective tracking patterns independently and the user selects the one required by switching to the appropriate channel.

Presentation would normally be made on a standard flight log mounted in the cockpit ; on this the ranging information will be displayed on a suitably scaled chart, the tracking scale varying

Fig. 2: Working principle of the Dectra system: station pairs AB and CD form two systems of hyperbolae which cover the route with tracking patterns (*left*); Master stations A and C lay down hyperbolic ranging patterns (*right*).





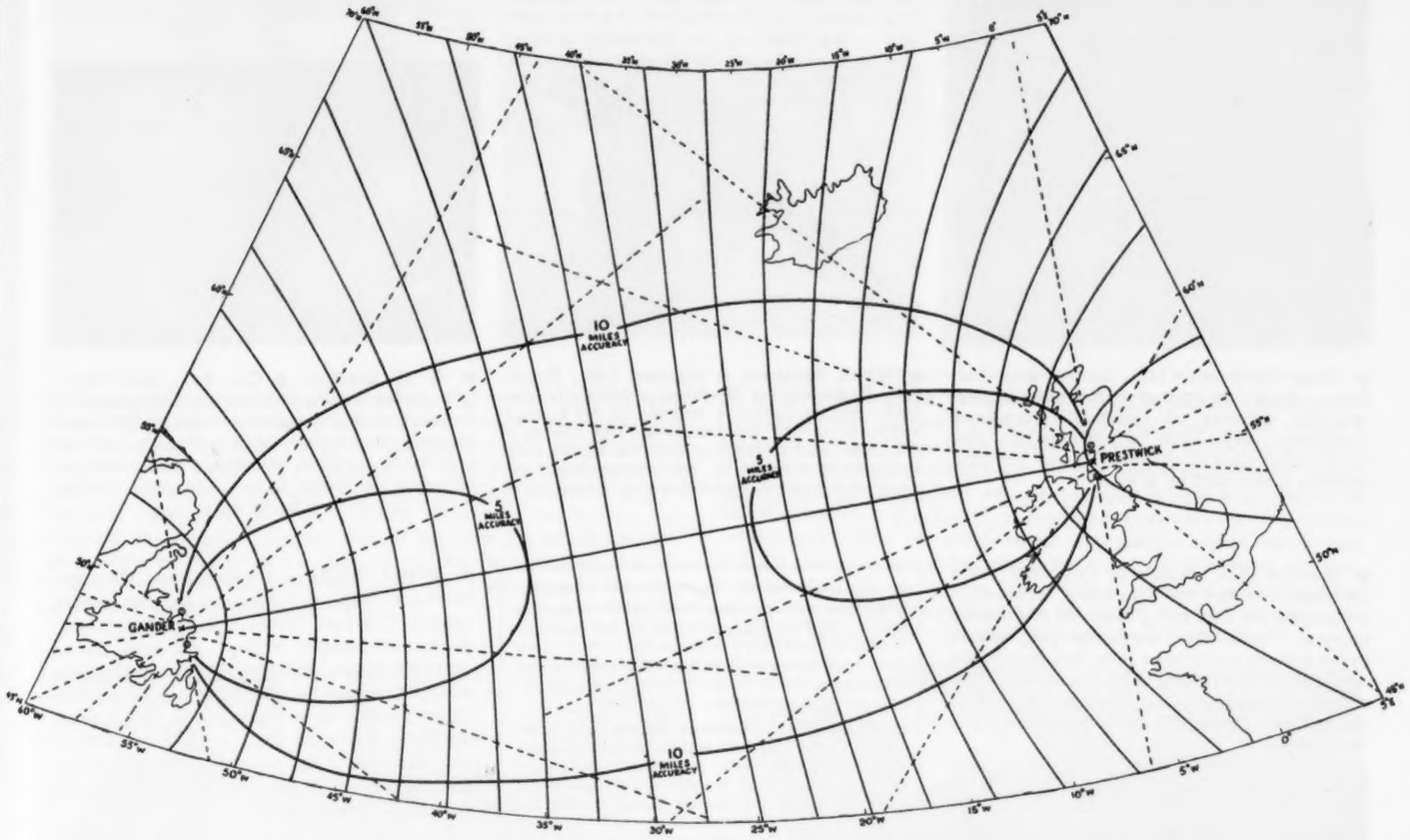
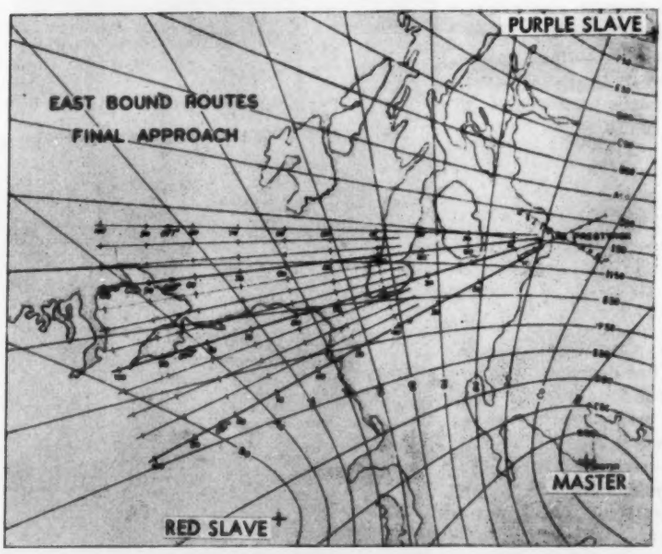


Fig. 3: Dectra plan for the North Atlantic route from Prestwick, Scotland to Gander, Newfoundland. The map scale is indicated by the latitude figures (10° = 600 nautical miles) approximately every 10 lanes of tracking patterns and every 100 lanes of ranging patterns are shown.

from 2 miles to the inch in terminal areas to 40 miles to the inch at mid-route. One chart is sufficient for a particular route so that no in-flight resetting will be required. Presentation may be on a meter display if desired, one meter indicating the distance to go, the other indicating lateral displacement from track. In this way the pilot has at his disposal a highly accurate yet flexible navigation aid which will permit him to use any of the techniques used today in transatlantic aviation whether flying Great Circle, pressure pattern or whatever the situation demands. One of the great advantages of the system is that the Dectra transmitters would normally form part of a standard Decca Chain so that in addition to the increasing accuracy of the Dectra System as the aircraft reaches either end of the route a change to standard Decca can be made by the pilot at any time he chooses. For the first time the pilot will have continuous information available as to his position at all times, so that he can maintain a predetermined track with great accuracy and detect any changes in wind conditions as they occur.

Fig. 4: Diagram of West-East approach courses to Prestwick. The ranging pattern overlaps the standard lattice of the North British Decca chain (No. 3), whose Master station and Red and Purple Slaves are also marked on the map. The base line between the Master and Purple Slave measures approx. 94 nautical miles.



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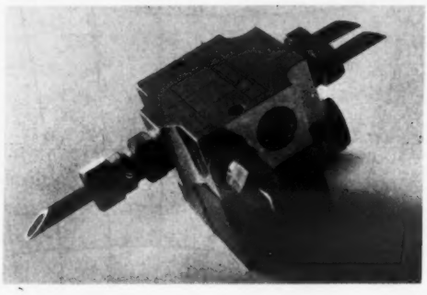
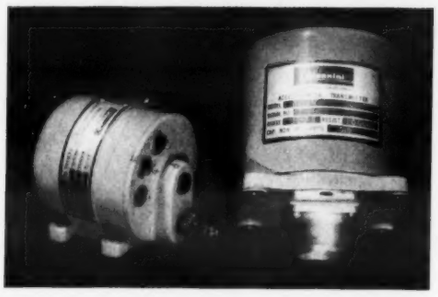
With the introduction of jet aircraft to the North Atlantic route and the diverse problems their control imposes to an already complex situation, such an aid is of vital importance. With their need to make controlled climbs and descents in and out of terminal airports and subjection to the meteorological conditions peculiar to high altitude flight it is essential that such aircraft have an adequate navigational aid available under all conditions. It is hoped that with M.T.C.A. and M.o.S. support, trials will take place in the coming autumn ; in this way extensive data will be acquired on the performance and operational aspects of the system so that it can be put at the disposal of North Atlantic traffic with the least possible delay.

Equipment Round-Up

● **Ekco Electronics Ltd.,** Southend-on-Sea, Essex : Type E 59 equipment for recording the radiation patterns of centimetric antennas (frequency range 9,300 to 9,500 mc/s). The whole equipment is mounted, along with the antenna under test, in a trailer.

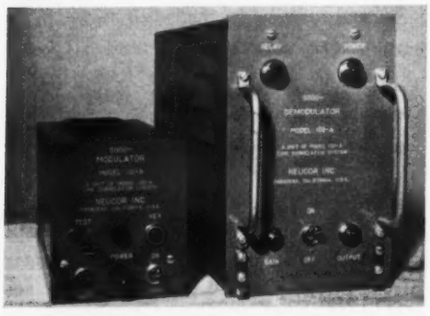


● **Short Brothers & Harland Ltd., Precision Engineering Division,** Belfast. N. Ireland : electro-hydraulic transducer for 2-stage hydraulic service mechanisms. The device is a simpler and cheaper alternative to the conventional system of an electromagnetic relay coupled to a spool-type slide valve. Dimensions $2\frac{1}{2} \times 2\frac{1}{4} \times 1\frac{1}{2}$ ins.



● **G. M. Giannini & Co., Inc.,** New York : type 24118 accelerometer with magnetically damped spring-supported mass (right-hand picture) ; measuring range $\pm$ 0.1 g to $\pm$ 30 g. Left, 45176 pressure transdducer with an output of up to 100 Volts D.C. ; measuring ranges from 0 to 5 up to 0 to 150 p.s.i.

● **Neucor Inc.,** Pasadena, California : time correlation system for data being recorded in an aircraft and data being recorded at a remote location. The 5,000 c/s modulator (left) carried in the aircraft energizes a relay that passes the modulated signal to the radio transmitter. The signal is then picked up by the second measuring station and used to energize a relay in the demodulator.



● **Arrowhead Rubber Co.,** a Division of National Motor Bearing Co. Inc., Long Beach, California, supplies flexible " Flo-Flex " fluid connectors of high resistance to vibration, temperature variations etc. They are made of rubber-impregnated fibreglass with a seamless liner of specially compounded synthetic elastomers, and can be supplied in all diameters and lengths.

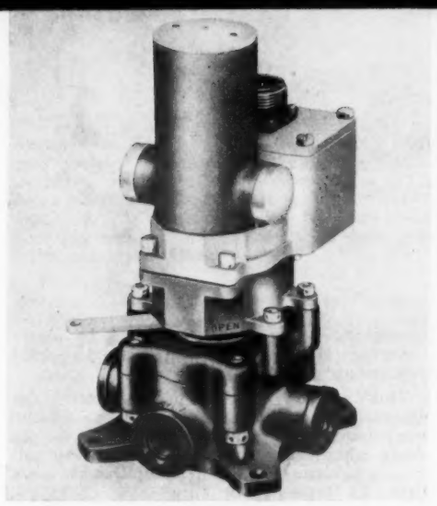
● **General Electric Company, Aircraft Gas Turbine Division :** the materials testing laboratory recently experimented with plastic compressor blades which are considerably lighter in weight and cheaper to produce than forged steel blades. During the test programme five compressor stages in a J-47 jet engine were fitted with blades of reinforced phenolic resin and tested for more than 100 hours with successful results. As the maximum operating temperature of these blades is at present limited to 500° F, they are not yet suitable for use in modern jet engines with very high compression ratios.

● **Vickers Inc.,** Detroit, Michigan, produces four-way closed-centre solenoid selector valves for use in aircraft hydraulic systems. Fluid temperature up to 150° C (return-fluid temperature up to 200° C), maximum operating pressure 4,500 p.s.i.

● **Vapor Heating Corporation,** Chicago, Illinois, supplies this overheat warning control (Vapor Thermal Switch 3162) for bearings, gears and electric motors. As soon as an overheat temperature of 275° F occurs, the mercury contact thermostat causes a warning signal to light up in the cockpit. The control, weighing only 0.065 lbs., can be threaded into a $\frac{3}{8}$ inch tap in the bearing housing, and one electrical contact is grounded to the metal housing of the control.

● **Centre d'Etude de Biologie Aéronautique** has developed for the French Air Force a high-altitude pressure suit which also serves as an anti-G suit. As altitude increases, the nylon fabric suit automatically shrinks, maintaining a constant pressure on the whole of the body. For breathing purposes pure oxygen is fed to the helmet under pressure.

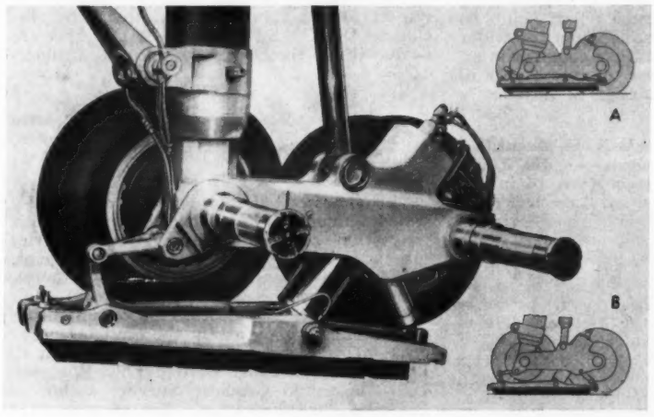
● **The U.S. Navy's Clothing Supply Office,** Brooklyn, N. Y., has developed a one-piece airtight protective suit for crews handling highly corrosive rocket propellants (smoking nitric acid etc.). The suit is made of cotton fabric coated with resin-treated butyl rubber ; air for breathing and ventilation is fed through a tube via a specially protected valve.



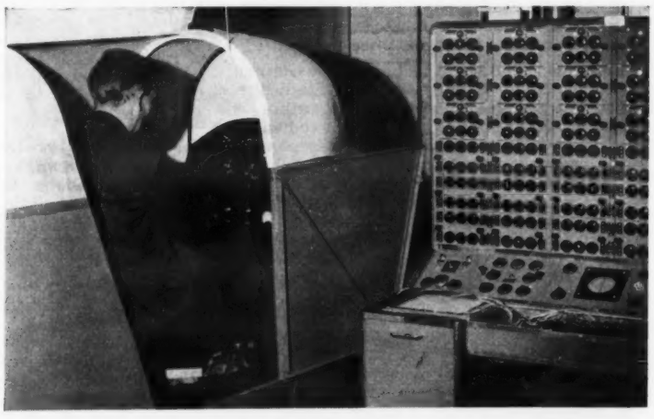
● **General Control Co.,** Glendale, California, produces motor-operated four-way rotary selector valves for aircraft hydraulic systems with working pressures up to 3,000 p.s.i. The equipment is designed for working temperatures of —65 to + 275 degrees F. The 24-Volt D.C. motor changes the valve position in half a second at —65° F.

● **General Electric Company, Aircraft Gas Turbine Division,** Evendale, Ohio, is investigating the possibilities of honeycomb construction for jet engine parts. Here a honeycomb core which is very much lighter in weight than conventional solid construction of the same strength.

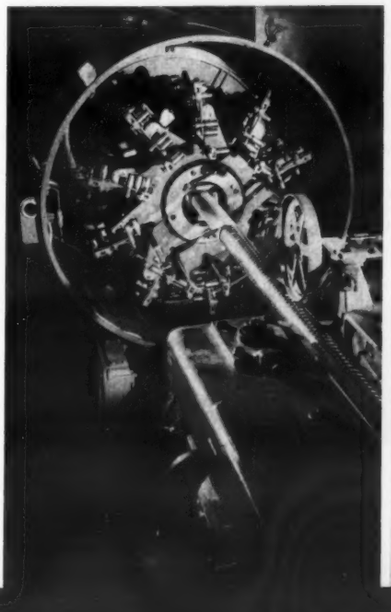
● **Dowty Equipment Ltd.,** Cheltenham, Gloucester, has developed a new type of runway brake, which has been fitted in the main undercarriage unit of the Avro *Vulcan* jet bomber (picture). A hydraulically operated brake shoe with shaped pad of special synthetic rubber is extended, after the aircraft's touch-down (A), until it carries 80% of the aircraft's weight (B), thus considerably shortening the landing run. Although the wheels carry only 20% of the load, the aircraft remains controllable by means of the nose wheel. As the spring effect of the tyres is lost, a self-contained air spring has been fitted in the main operating cylinder of the brake shoe.



● **Short Brothers and Harland Ltd.,** Belfast, N. Ireland : the Research Department has designed an aircraft handling simulator to enable a projected aircraft design to be " flown " before it is built. The simulator consists of a dummy cockpit with normal pilot's controls and instruments, used in conjunction with an analogue computer on which the basic aerodynamic qualities of the projected aircraft are set. The control column and rudder bar are provided with potentiometers which feed voltages into the computer proportional to the simulated elevator, aileron and rudder movements. If handling qualities are not found satisfactory, the aircraft's characteristics can be modified by adjusting the computer settings until the desired response is obtained.



● **Pirelli-General Cable Works Ltd.,** Eastleigh, Hants, an associate of the General Electric Co. Ltd. and Pirelli, Milan, has recently installed a new paper-lapping machine for use in cable manufacture. Picture shows the machine's 20 lapping heads applying insulating paper tape to an oil-filled 301 kV cable. Right, section through the oil-filled 301 kV cable ; from centre outwards : oil duct, conductor wires, paper insulation, protective lead sheath, silicon bronze reinforcement, protective casings of rubber and proofed cloth.



● **Sylvania Electric Products Inc.,** New York : twenty Sylvania Strobeacon units with xenon flash tubes have been installed along the approach path to New York International Airport. Each has a beam of over 30,000,000 candle power and flashes twice a second (flash duration 200 microseconds). The flashes are arranged in consecutive order from the outermost to the innermost unit, giving the impression of an arrow of light pointing to the runway.

Book Reviews

High Speed Aerodynamics and Jet Propulsion—Volume II, Combustion Processes. Edited by B. Lewis, R. N. Pease and H.S. Taylor. Princeton University Press, Princeton, New Jersey, 1956 (English, 662 pages, price $12.50).

Prepared with the same care as previous volumes (I, VI and IX) in the collection, Volume II gives an introduction to the complicated combustion processes in gas turbines and rocket power plants . The many complementary theories developed in recent years with a view to gaining a clearer idea of the validity of aerodynamic and thermodynamic laws are collected in condensed form in this book. The five main sections (Thermodynamics of Combustion, Chemical Kinetics of Combustion, Flame Propagation in Gases, Combustion of Liquids and Solids, Detonation Processes in Gases, Liquids and Solids) are followed by a section on Energy Production by Nuclear Reactions. Re.

Einführung in die Hubschraubertechnik. By Dr.-Ing. W. Just (published as Report 11 of the German Helicopter Study Group, Stuttgart). Ernst von Olnhausen, Stuttgart, 1955 (German, 185 pages, price DM 14).

As technical and scientific head of the German Helicopter Study Group (Deutsche Studiengemeinschaft für Hubshrauber), the author is ideally placed to provide an expert introduction into helicopter engineering. Every pilot, engineer or mechanic who has to deal with helicopters will find in his book a precise account of all important questions, from the methods of compensating torque to maintenance and inspection regulations, together with type data, tables of design parameters, structural examples, etc. Other chapters give a historical survey, basic aerodynamic notions, roof heliports. Finally, the author proposes a classification of all helicopter activities into 25 domains, a classification which has already been accepted by the German Helicopter Research Group as a working basis. Re.

Ergebnisse der Deutschen Böenmessungen 1939/1941. — By Prof. H. Koschmieder (Vol. 2 in the series " Flugmeteorologische Forschungsarbeiten "). Verlag Friedr. Vieweg & Sohn, Brunswick, 1955 (German, 148 pages, DM 14).

Systematic gust measurements designed primarily to determine the extent of gusts in space and time were made near the Lindenberg Aeronautical Observatory between 1939 and 1941. With the aid of a special network of meteorological stations set up for the purpose, isotherms were constructed for the gust areas, and variations in vertical mass distribution recorded (by ballon-sondes). The present booklet collects the data obtained in tabular and graphic (synoptic) form and gives a detailed explanation of the results, with description of the weather conditions attending each measurement. Re.

Zur Aerodynamik des Ringflügels. Die Druckverteilung dünner, fast drehsymmetrischer Flügel in Unterschallströmung. — By Prof. Dr. rer. nat. J. Weissinger (Vol. 198 in the series of research reports published by Prof. Leo Brandt, North Rhine-Westphalian Ministry of Economics and Transport). — Printed in manuscript form by Westdeutscher Verlag, Cologne and Opladen, 1955 (German, 30 pages, price DM 9).

Since the design of the coleopter has reawakened interest in the annular wing there has been a need to adapt the theory of plane wings to the annular wing, i.e., to find methods of calculating pressure distribution, lift and induced drag, in particular in oblique flow. This requirement is largely met by the analogy with the normal wing theory developed by the author. The connection between induced drag and lift resembles that in a wing of elliptical chord distribution. The author also gives approximation formulae for ascertaining the neutral point which are sufficiently close to the actual values within the aspect ratio range that is of practical interest. Re.

Schwingungsverhalten eines Schaufelkranzes im Vakuum. — By Dr.-Ing. H. Söhngen (Vol. 191 in the series of research reports published by Prof. Leo Brandt, North Rhine-Westphalian Ministry of Economics and Transport). Printed in manuscript form by Westdeutscher Verlag, Cologne and Opladen, 1955 (German, 24 pages, price DM 7.80).

The author has studied blade oscillations in the blade rings of axial compressors for the German Aeronautical Research Establishment, with special reference to oscillation couplings through the blade foot (effect on neighbouring blades). The present research report points to the similarity between the oscillation behaviour of rotating blade rings and gas columns in an annular tunnel and stresses the importance of this resemblance in the design of turbines. Re.

Die Steuerung des Gaswechsels in Schnellaufenden Verbrennungsmotoren. — By Dipl.-Ing. Wolf-Dieter Bensinger (Vo. 16 in the series " Konstruktionsbücher " published by Prof. Dr.-Ing. Kollmann). — Springer-Verlag, Berlin, Göttingen and Heidelberg, 1955 (German, 92 pages, price DM 12).

A valuable aid to the engine designer. The author discusses with the aid of cut-away drawings, the qualities of gas controls, divided into valve and sleeve valve designs. The chapter " Calculating Control Elements " lists a large number of design parameters adapted to recent engineering developments. Derivatives of formulae have been dispensed with in favour of detailed examples of calculations. At the end of the book the author describes his work on rotary slide valve steering at the German Aeronautical Research Establishment, the results of which were not published at the time because of security regulations. Re.

Nerven, Herz und Rechenschieber—Kurt Tank, Flieger, Forscher, Konstrukteur. By Heinz Conradis. Musterschmidt, Göttingen/Frankfurt/Berlin, 1955 (German, 379 pages, price DM 14.80).

A both stimulating and detailed biography of the well-known German aircraft designer Kurt W. Tank, whose jet fighter designs are still reflected in aircraft types in use today. The author is a former colleague of Tank's and is thus doubtless in a position to paint an accurate picture of his life and activity. He.

Au-delà du Son. By P.-M. Lambermont.—La Table Ronde, Paris, 1955 (French, 187 pages).

An entertainingly written history, spiced with numerous anecdotes, of supersonic flight, from the first tentative efforts of the pioneers to today's jet, ramjet and rocket aircraft. A French pilot who was at Farnborough during Whittle's first practical experiments, the author knows how to interest the young in his subject. A number of errors in the spelling of foreign, particularly German, names and words could readily be corrected in later editions. He.

Deutsche Segelflugzeuge. Published by Aero-Verlag Hubert Zuerl, Munich 15, 1954 (German, 62 pages).

This survey of German postwar glider designs gives a good account of the fruitful work done by German designers during the ten years when construction of powered aircraft was forbidden. The booklet describes no fewer than 43 types (with three-view drawings), from simple training gliders for home construction to high-performance sailplanes with an L/D ration of more than 30. A pocket book to be recommended to all gliding enthusiasts. Re.

Les flottes de combat 1956, by H. and J. Le Masson. Editions Maritimes et Coloniales, Paris (French, 360 pages, photos and drawings price 3,000 French francs).

The 1956 Edition of this well-known reference work gives all the information at present available on atomic submarines, giant aircraft carriers, the guided missile ships that appeared last year and which seem to be the prelude to as big a revolution as that of the replacement of sail by steam. The navies of the world, including the U.S.S.R., and their air arms are dealt with in the customary accurate manner. La.

Practical Air Navigation (7th Edition).—By Thoburn C. Lyon.—Aeronautical Services, Annapolis, Maryland, 1955 (English, 407 p., numerous illustrations, price $3.00).

This compact but thorough new edition of a widely circulated handbook on practical air navigation can scarcely be given a better recommendation than that of P. V. H. Weems. —Lieutenant Commander Weems (U.S. Navy), himself the author of a standard work on air navigation, writes : " Not often does an author of a technical book attain the ' million copy ' class. This high honour goes to Thoburn C. Lyon, formerly Chief Cartographic Engineer, U.S. Coast and Geodetic Survey, author of Practical Air Navigation. The seventh 1955 edition is a complete and thorough revision of the entire text. Sections are included on Radio Navigation, Pressure Pattern Flight, Celestial Navigation and Polar Navigation. I consider Practical Air Navigation to be one of the outstanding text books on air navigation for student and professional use . . ." Ri.

La Convention de Rome du 7 octobre 1952 relative aux dommages causés par les aéronefs aux tiers à la surface. By Michel de Juglart. Les Editions Inter-Nationales, Paris, 1955 (French, 224 pages, price 1,300 French francs).

Michel de Juglart, Professor of Air Law at the University of Bordeaux and author of a well-known textbook on air law (" Traité Elémentaire de Droit Aérien "), here gives an exceptionally clear account of the principles underlying the second Rome Convention (liability of the aircraft operator for damage to third parties on the surface). His book might also be entitled " The sorrowful tale of an international agreement ": although more than two decades have passed since the signature of the first Rome Convention (May 29th, 1933), and although the Brussels Protocol was added on September 29th, 1938 to provide the necessary insurance protection, the Convention has never received the required number of ratifications. In the second Convention (1952) the liability regulations have been considerably watered down to make them more attractive to go-

vernments.—Publication of de Juglart's book was justifiably financed by France's Centre National de la Recherche Scientifique. The work is not only instructive to the air law expert but concerns everyone who has ties with aviation and regrets its hesitating legal and economic development. He.

Principes de Droit International Privé applicables aux actes accomplis et aux faits commis à bord d'un aéronef. By Flavie de Planta. Published with the support of the Fonds Godefroy by Librairie E. Droz, Geneva, 1955 (French, 188 pages, price Sw.fr. 12.00).

Up to the present there are no international conventions on civil law to be applied on board aircraft. As, however, air transport is essentially international in nature, and its importance in everyday life is constantly growing, it is high time that standard rules were evolved for dealing with legal procedures (signature of contracts, negotiations etc.) taking place during an air journey. The International Law Association and I.C.A.O. have already prepared draft agreements for the standardization of criminal law principles. Similar preparatory work has now been done in the field of civil law by the present study which—despite its somewhat complicated title—gives a clear survey of the material that would have to be covered in an international convention. He.

Technique et utilisation des jauges de contrainte. By U. Zelbstein, Technical Director of S.A. SEXTA. Dunod, Paris, 1956 (French, 255 pages, 200 illustrations, price 1,880 French francs).

Theories of resistance and elasticity have not always been adequate to solve all the problems raised by the choice of structural material and the determination of its shape and dimensions. Today the engineer can use strain gauges to check the accuracy of his forecasts, either to prepare future modifications or to confirm projected characteristics. Strain gauges directly measure the strains to which material is subjected and can be used to solve practically all measurement problems, either with a view to direct utilization of results or as detector elements. The present work describes in full detail the use of strain gauges and their various types, with numerous illustrations. La.

Books Received

Publications scientifiques et techniques du Ministère de l'Air.—Distributed by the Service de documentation et d'information technique de l'Aéronautique, Paris :

No. N.T. 55 : *Etude thermique des écoulements d'air raréfié en régime moléculaire libre,* by F. Marcel Devienne.

No. N.T. 56 : *Mise en équations et résolution des réseaux électriques en régime transitoire par la méthode tensorielle,* by A. Kaufmann.

No. 301 : *Sensitométrie photographique,* by Maurice Roulleau.

No. 302 : *Nouveaux compléments d'hydraulique,* deuxième partie, by L. Escande.

No. 303 : *Mouvement oscillatoire avec viscosité et inertie,* by Claire Clarion.

No. 304 : *Contribution à l'étude de l'effet de paroi en écoulement plan incompressible,* by Jacques Barbieux.

No. 305 : *Contribution à l'étude des milieux poreux,* by Mladen M. Boreli.

No. 306 : *Introduction à la mécanique des milieux continus,* by Paul Anglès d'Auriac.

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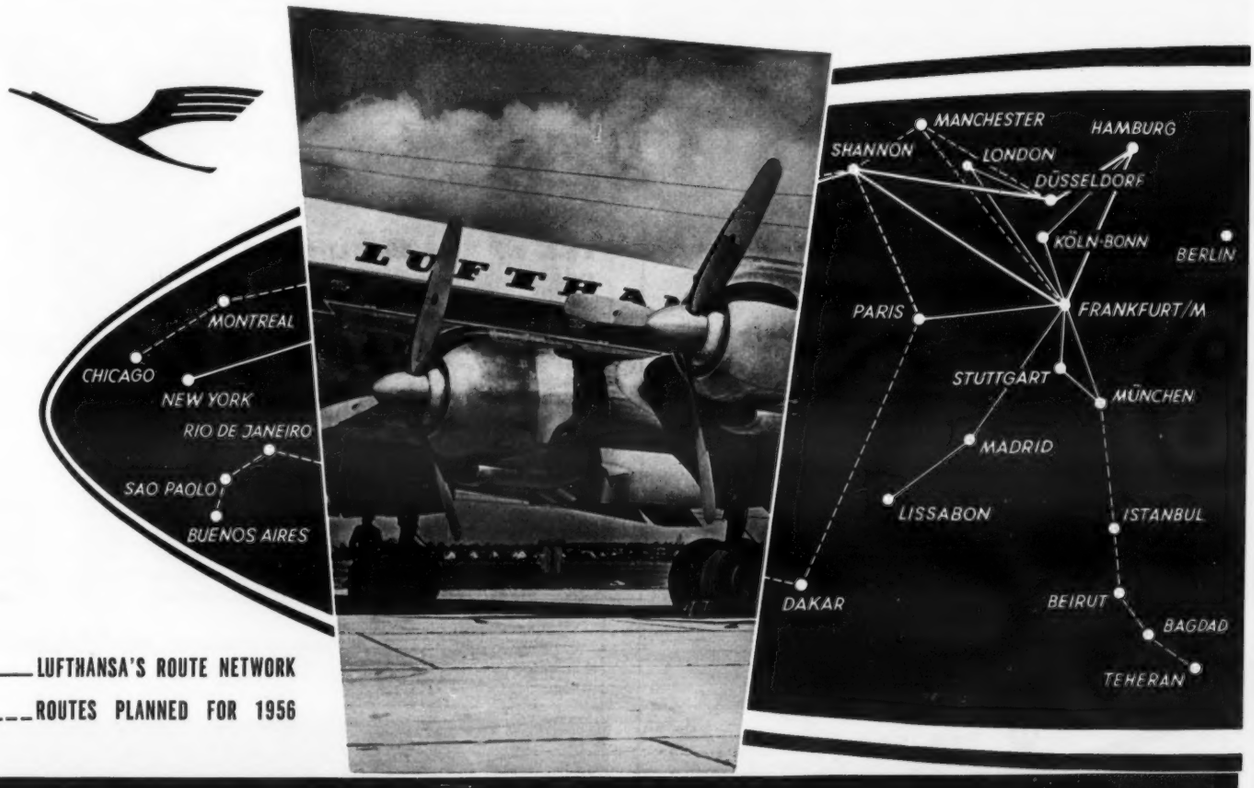

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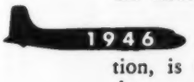

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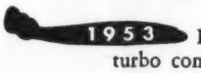

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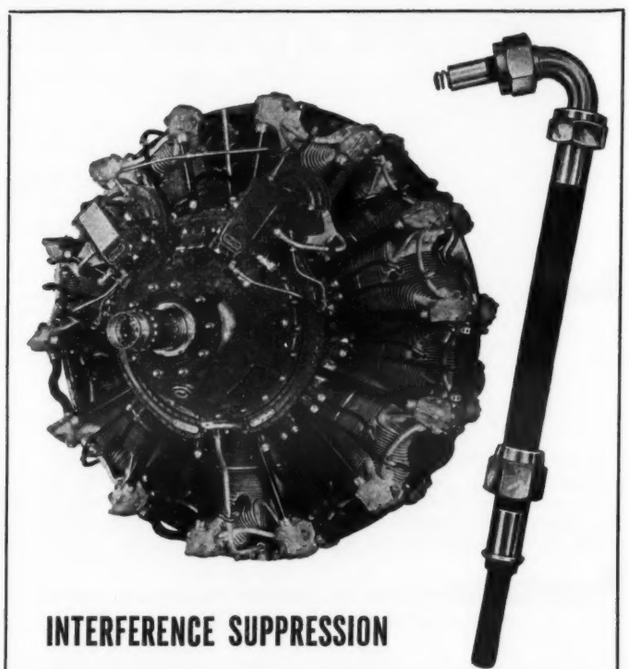

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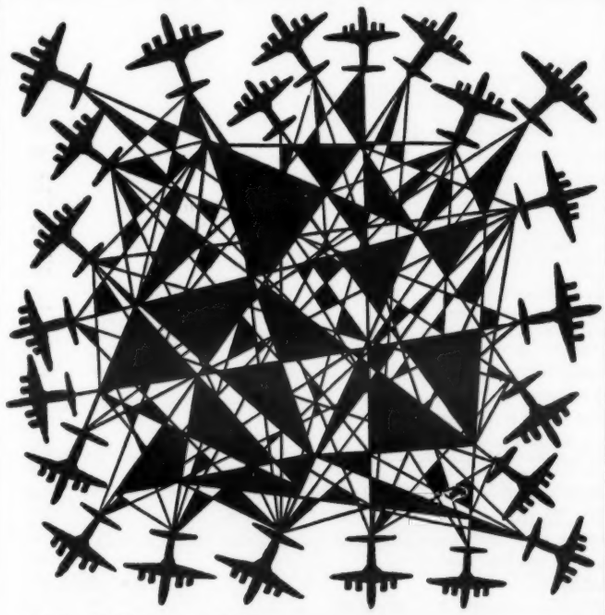

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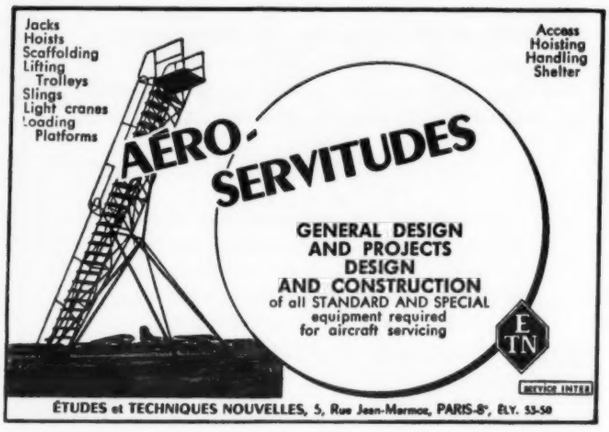

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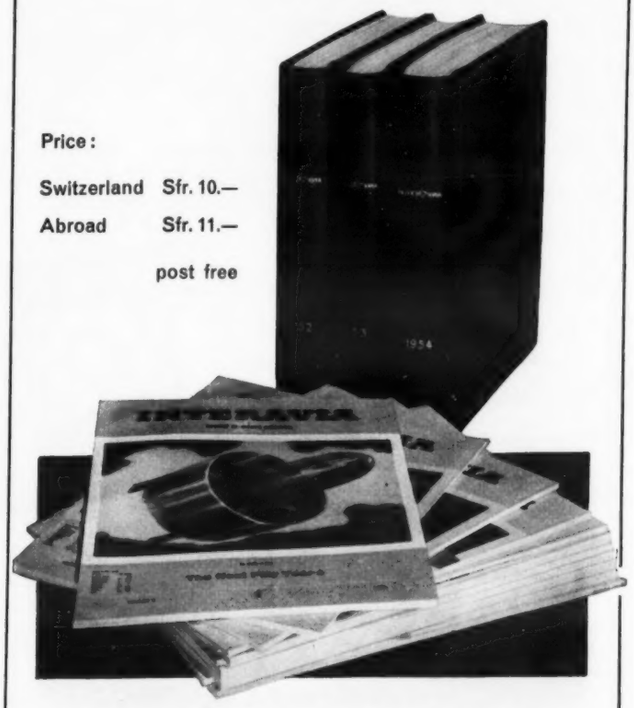

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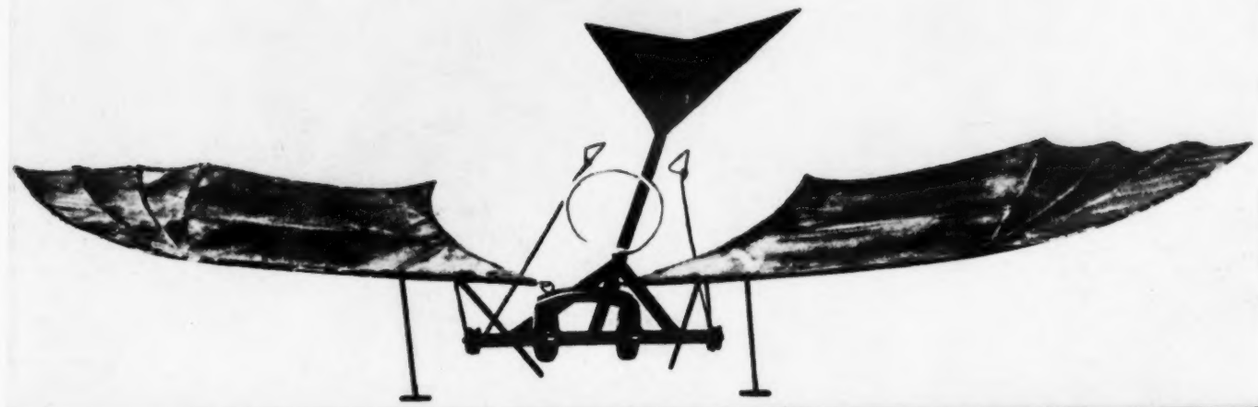

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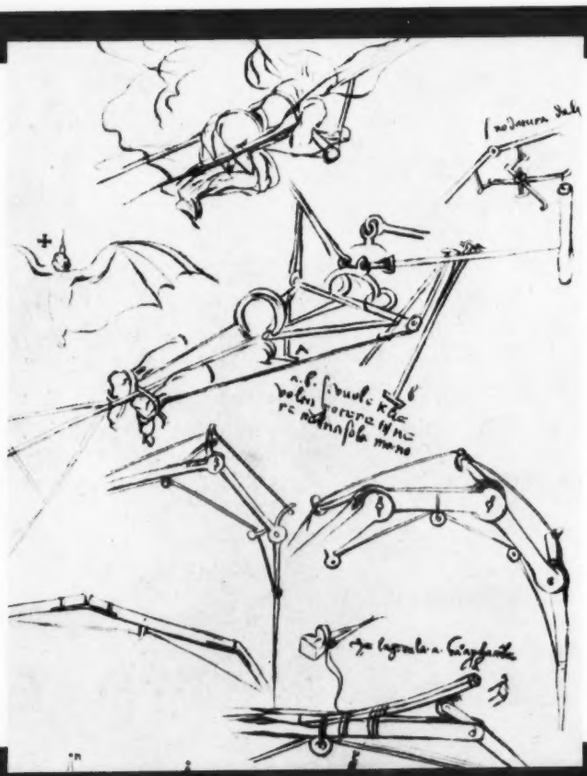

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